33d Congress, 2d Session. | SENATE. | Ex. Doc. No. 78.

REPORTS

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-4,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME V.

WASHINGTON:
BEVERLEY TUCKER, PRINTER.
1856.

MISSOURI BOTANICAL GARDEN LIBRARY

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IN SENATE—FEBRUARY 24, 1855.

Resolved, That there be printed, for the use of the Senate, ten thousand copies of the several reports of surveys for a railroad to the Pacific, made under the direction of the Secretary of War; and also of the report of F. W. Lander, civil engineer, of a survey of a railroad route from Puget's Sound, by Fort Hall and the Great Salt lake, to the Mississippi river; and the report of John C. Frémont, of a route for a railroad from the head-waters of the Arkansas river into the State of California; together with the maps and plates accompanying said reports, necessary to illustrate the same; and that five hundred copies be printed for the use of the Secretary of War, and fifty copies for each of the commanding officers engaged in said service.

Attest: ASBURY DICKINS, *Secretary*.

THIRTY-SECOND CONGRESS, SECOND SESSION—CHAPTER 98.

SECT. 10. *And be it further enacted*, That the Secretary of War be, and he is hereby authorized, under the direction of the President of the United States, to employ such portion of the Corps of Topographical Engineers, and such other persons as he may deem necessary, to make such explorations and surveys as he may deem advisable, to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean, and that the sum of one hundred and fifty thousand dollars, or so much thereof as may be necessary, be, and the same is hereby, appropriated out of any money in the treasury not otherwise appropriated, to defray the expense of such explorations and surveys.

Approved March 3, 1853.

THIRTY-THIRD CONGRESS, FIRST SESSION—CHAPTER 60.

Appropriation: For deficiencies for the railroad surveys between the Mississippi river and the Pacific ocean, forty thousand dollars.

Approved May 31, 1854.

THIRTY-THIRD CONGRESS, FIRST SESSION—CHAPTER 267.

Appropriation: For continuing the explorations and surveys to ascertain the best route for a railway to the Pacific, and for completing the reports of surveys already made, the sum of one hundred and fifty thousand dollars.

Approved August 5, 1854.

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REPORT OF LIEUTENANT R. S. WILLIAMSON, CORPS OF TOPOGRAPHICAL ENGINEERS, UPON THE ROUTES IN CALIFORNIA TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS.

REPORT

OF

EXPLORATIONS IN CALIFORNIA

FOR

RAILROAD ROUTES,

TO CONNECT WITH

THE ROUTES NEAR THE 35TH AND 32D PARALLELS OF NORTH LATITUDE,

BY

LIEUTENANT R. S. WILLIAMSON,

CORPS OF TOPOGRAPHICAL ENGINEERS.

1853.

LETTER TO THE SECRETARY OF WAR.

WASHINGTON, *December* 31, 1854.

SIR: I have the honor herewith to submit to you the following report of a reconnaissance and surveys on partial routes in California, connected with surveys for ascertaining the most practicable railroad route from the Mississippi river to the Pacific ocean.

I present in connexion with this report a geological report by Mr. W. P. Blake, geologist and mineralogist of the expedition, illustrated by maps, sections, and views.

Dr. A. L. Heermann, the physician and naturalist of the expedition, made a large natural history collection; and among the fish, reptiles, and plants are found many species hitherto unknown. The collection of California birds is a very fine one, it containing more than one hundred and twenty species.

These collections in different departments of natural history have been examined, and the descriptions, accompanied by figures, will appear in a separate volume. Dr. Heermann will present a report on the birds; Professor Spencer F. Baird, of the Smithsonian Institution, on the mammalia; Dr. E. Hallowell on the reptiles; and Charles Girard on the fish. The plants will be described by Dr. Hilgard and Mr. Durand, of Philadelphia.

The sketches which accompany this report were made by Charles Koppel, assistant civil engineer, and they will serve as aids in forming a correct idea of the nature of the country.

I have to thank my associates in this survey for the great interest they took in the expedition, and the cheerful and thorough manner in which the work was performed. Lieutenant Stoneman, commanding the escort, rendered me every assistance in his power. Lieutenant Parke was of very great assistance to me, taking charge of a party whenever the main party was divided, which was generally the case. Mr. Smith proved himself to be a very competent civil engineer. The reports of Dr. Heermann and Mr. Blake at once show the nature of their labors, and the manner in which they were performed. In fact, every member of the party was unceasing in his endeavors to advance the objects of the expedition.

I have the honor to be, very respectfully, your obedient servant,

R. S. WILLIAMSON,
Lieutenant U. S. Top. Engineers.

Hon. JEFFERSON DAVIS,
Secretary of War.

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INTRODUCTION.

INSTRUCTIONS FROM THE WAR DEPARTMENT.

War Department, *Washington*, *May* 6, 1853.

Under the 10th and 11th sections of the military appropriation act approved March 3, 1853, directing such explorations and surveys to be made as might be deemed necessary "to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean," it has been determined to organize a party to operate in California, to survey and explore the country lying west of the lower Colorado, and a route connecting that portion of California with the Pacific ocean.

I. The party for this exploration and survey will be commanded by Lieutenant R. S. Williamson, topographical corps, who will be aided by Lieutenant J. G. Parke, topographical corps, and by the following civil assistants, viz: one mineralogist and geologist; one physician and naturalist; two civil engineers; one draughtsman: who, in addition to their stipulated compensation, will be allowed the actual cost of their transportation to and from California. Packers, &c., will be employed in California, at prices not exceeding those paid by the Quartermaster's department for such employés.

II. The party will rendezvous at Benicia, in California, and, having organized, will proceed to examine the passes of the Sierra Nevada leading from the San Joaquin and Tulare valleys, and subsequently explore the country to the southeast of the Tulare lakes, to ascertain the most direct practicable railroad route between Walker's Pass, or such other pass as may be found preferable, and the mouth of the Gila; from this point the survey will be continued to San Diego.

III. In this exploration, great attention will be paid to every point connected with the location of a railroad. A general profile of the route explored will be determined by means of barometric measurements; and, generally, the topography, meteorology, geology, natural history, the character of the Indian tribes of the country, &c., will be studied as closely as circumstances will permit.

IV. The commanding general of the Pacific division will assign an escort of mounted troops to accompany the expedition, consisting of not less than three non-commissioned officers and twenty-five privates. Picked men and horses only will be sent on this duty; and the commanding officer of the escort will be instructed to furnish Lieutenant Williamson such aid and assistance as will tend to facilitate his operations. Transportation for the provisions, equipage, &c., of the escort, will be furnished by the Quartermaster's department.

V. Lieutenant George B. Anderson will be detailed for duty with Lieutenant Williamson's party.

VI. The Quartermaster and Commissary departments will furnish to Lieutenant Williamson such animals, equipments, stores, provisions, and other public property, as he may need for the use of the expedition, and which can be spared, to be paid for out of the appropriation for the survey, at cost at the places of delivery. On the requisitions of Lieutenant Williamson, the Ordnance department will furnish arms, &c., and the Medical department medicines, &c., for his party.

VII. The object of the expedition having been accomplished, all employés whose services may be no longer required will be discharged, and Lieutenant Williamson, with the office corps, will proceed to prepare as full a report as possible, to be laid before Congress, as required by the act above cited, on or before the first Monday in February next, to be followed at a later period by a more elaborate report, showing in full the results of the expedition.

VIII. The sum of thirty thousand dollars is set apart, from the appropriation, for the expenses of the survey thus intrusted to Lieutenant Williamson.

JEFFERSON DAVIS,
Secretary of War.

PART I.

VIEW OF BENICIA FROM THE WEST.

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

ROUTES IN CALIFORNIA, TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, EXPLORED BY LIEUT. R. S. WILLIAMSON, CORPS OF TOPOGRAPHICAL ENGINEERS, IN 1853.

REPORT.

WASHINGTON, D. C.
1855.

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* From original sketches in the field by Mr. Charles Koppel

ORGANIZATION OF PARTY.

The instructions from the War Department were received by me on the day after their date, and I immediately took steps for forming the party, and collecting the material necessary for the successful prosecution of the duties assigned to me; and knowing the importance of the utmost despatch, as the season must necessarily be far advanced before we could reach California, I deferred all the preparations that could be made while the outfit was being prepared, and taking with me only such instruments as I knew could not be procured there, I embarked with my party at New York on the 20th May, on board the steamer Illinois, bound for Aspinwall.

The party which embarked with me consisted of Lieutenant J. G. Parke, topographical engineers; Lieutenant G. B. Anderson, 2d dragoons; Dr. A. L. Heermann, physician and naturalist; Mr. Isaac Williams Smith, civil engineer; Mr. Charles Koppel, assistant civil engineer and artist; Mr. Charles Preuss, draughtsman. Lieutenant George Stoneman, 1st dragoons, who had been detailed to command my escort, was also on board.

It will be perceived that an important member of the party, the mineralogist and geologist, was absent. I had used every exertion to obtain one, writing to many persons who had been recommended to me, but could find no one to fill this important post. My only resource was to request Professor Spencer F. Baird, of the Smithsonian Institute, to endeavor to engage some one for me, who would follow at a later period. Thanks to the kindness of this gentleman, and much to my satisfaction, Mr. W. P. Blake was engaged, and he arrived at San Francisco a fortnight after us, and has since filled the vacant post.

The party arrived safely in San Francisco on the 20th of June, the only incident of note to us that occurred on the voyage being the illness of Lieutenant Anderson. This officer was attacked with fever shortly after leaving Panama, and arrived in San Francisco in a precarious state—so much so that the surgeon considered it would be dangerous for him to accompany us in the field. I therefore was forced to dispense with his services, but am happy to be able to state that he has since perfectly recovered.

I immediately repaired to Benicia, where preparations were at once commenced for fitting out the party. Such instruments as were required beyond those brought from New York were either obtained from the topographical office or purchased in San Francisco. A spring-wagon for their transportation was purchased. Four six-mule teams were furnished by the quartermaster for transportation of stores and baggage. Five teamsters and eight additional men for general duty as field-men and cooks were hired. In the mean time the escort had arrived, and it was found that to render it efficient it would be necessary to remount the men, whose horses, worn out in service, were condemned. Mules for this purpose were purchased by order of the

commanding general of the division. In fine, all the preparations were completed, and the party ready to leave Benicia, on the 10th of July.

GENERAL REMARKS.

Before proceeding to give a detailed narrative of our work in the field, I think it would tend to a more clear understanding of the subject if I were to give a concise description of the great topographical features of the country about to be examined, and the main objects, as I understood them, to be attained by this survey.

Benicia, the depot where the party was fitted out, is the northernmost point mentioned in my instructions. This town is situated on the Straits of Carquines, through which the waters of the Sacramento and San Joaquin rivers flow into San Francisco bay and the Pacific. From these straits to the southward, following the general course of the coast, is a range of mountains, extending beyond the southern boundary of this State into the peninsula of Lower California. This range often presents the appearance of several ridges, sometimes parallel, sometimes nearly at right angles; but there is one line, or water-shed, nearly parallel to the coast, and distant from it from 50 to 70 miles, which is unbroken by any water-course from San Francisco bay to Lower California. From this water-shed numerous short streams flow, meandering between the spurs or secondary ridges of the one great and continuous range, and forming rich and fertile valleys. This range varies in height from 800 to 5,000 or 6,000 feet. It is generally known as the Coast range, and this will be understood as its meaning where this term is used in this report.

If from Benicia we travel due east for about 120 miles, we will be at the summit of a much higher range than the one last mentioned, and following its water-shed southwardly, we find it gradually approaches the coast, until, in latitude 35° 20′ N., it actually joins itself to the Coast range, and the two are blended into one.

This is the Sierra Nevada, and varies in height from 4,000 to 8,000 and 10,000 feet. These mountains have a numerous population of miners, and though they have not been examined instrumentally but at two or three points, they have been so thoroughly "prospected" by the miners, that it is well known in the latitude of Benicia they are high and rugged, whereas near their junction with the Coast range they are much lower.

Mr. Blake considers the mountains south of this point of junction as the prolongation of the Sierra Nevada rather than the Coast range, and in his report he has proposed the name *Bernardino Sierra* for that portion of the chain extending from the end of the Sierra Nevada to the peak of San Bernardino.

Between the western base of the Sierra and the eastern base of the Coast range is the vast plain of the San Joaquin and Tulare valleys, being 300 miles long, and averaging 65 miles in breadth. These valleys are well watered by numerous streams flowing from the Sierra, though not one of consequence reaches them from the Coast range. The result of this is, that the traveller going along the western side of these valleys will find no stream, while on the eastern side he will find one every few miles. In the southern part of the plain are several lakes, called the Tulare lakes, and hence this part receives the name of the Tulare valley; while farther north, the San Joaquin river, coming from the Sierra, flows through the middle of its valley—a continuation of the other—in a northwest direction, receiving numerous tributaries from the east.

To the east of both the Sierra and Coast range, the country is very little known, and very

different accounts have been given of it by the few who have explored small portions of it. It has been represented by many as being in parts vast plains, while others, who have explored perhaps different parts, make it very broken and mountainous. No streams flow from it through the Coast range; and as most of the streams known to exist in it are known to lose themselves, it has been called, very properly, the "Great Basin."

It is evident that any railroad approaching the Pacific coast from the east must cross a portion of this Great Basin, when it will reach either the base of the Sierra Nevada or the Coast range, and, to reach the ocean, it must cross one or both of them. One main object of this survey is to ascertain if a railroad can cross the Sierra and Coast range; the other to explore the Great Basin, to ascertain its adaptability for such constructions.

As it is well known there is no impediment to the construction of a road to the Tulare valley from the waters of San Francisco bay, in order to accomplish the above objects I determined to proceed at once to the head of that valley, where the Sierra is supposed to be the lowest, and there examine all the passes leading into it.

FROM BENICIA TO LIVERMORE'S.

Benicia, formerly the capital of the State of California, is situated on the Straits of Carquines, which connect Suisun and San Pablo bays. It is on the north side of these straits, and is

STRAITS OF CARQUINES AND MARTINEZ, AS SEEN FROM BENICIA.

twenty-five miles above San Francisco. Adjoining the town is a military post and arsenal, and the principal depot of quartermaster and commissary stores for the department of the Pacific.

The depot and machine-shops of the Pacific Mail Steamship Company are also at this place. A view of a portion of the town and the landing is presented in Plate I. The double peak of Monte Diablo, distant fifteen miles, is seen in the background.

On the 10th of July I left Benicia, crossing my train and party to Martinez in the little ferry-boat which plies across the straits.

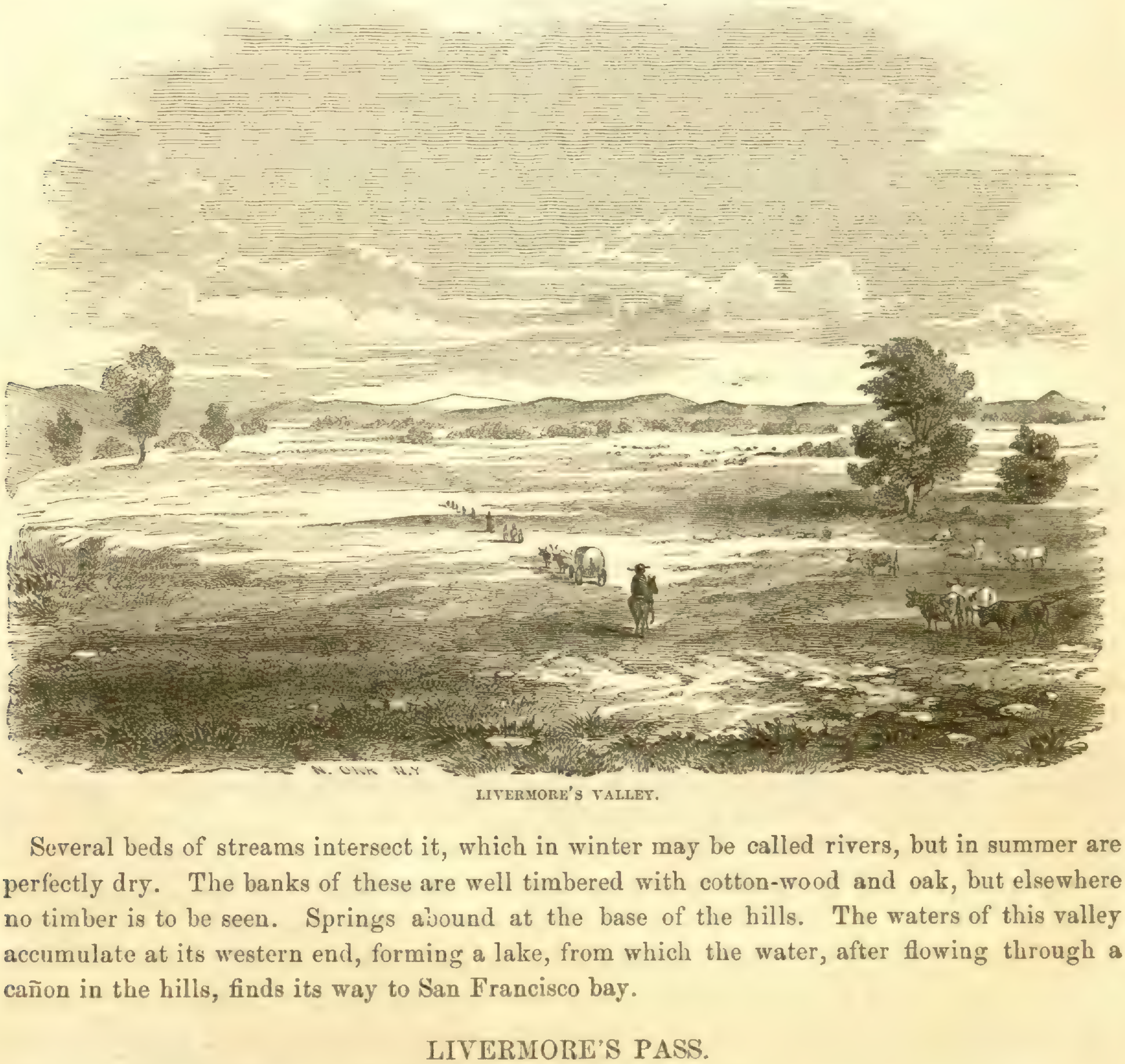
This town is situated in a pretty little valley, having a range of low hills on either hand—that on the east separating it from the San Joaquin valley. To reach this latter, from Martinez, on horizontal ground, would be very easy—following the shore of the bay and turning the point of hills. But this route would be rather circuitous, and I therefore preferred to take the ordinary road, and cross the Coast range more to the south, at a pass known as Livermore's; which pass I believed would, upon examination, prove a practicable one. The whole of the first day was occupied in crossing our teams and mules, and the next morning we moved, in a southeasterly direction, up the little creek upon which Martinez is built. To our left was Monte Diablo, a fine peak in the Coast range, and nearly 4,000 feet high—the highest for a long distance. At its base is the finest and most beautiful valley in this vicinity, about fifteen miles long and three or four broad. It is covered with oaks, and is somewhat celebrated for its excellent quarries of limestone.

MONTE DIABLO VALLEY.

In proceeding towards Livermore's valley, we have a range of hills on either hand; that on the right abounding in red-wood. Several saw-mills are established there, and supply San Francisco with large quantities of lumber. Our road was in the intermediate valley, which is

from one-half to two miles wide, and, to the eye, perfectly level. We are, however, at first ascending the little stream which waters Monte Diablo valley, and subsequently get upon ground descending in the contrary direction. The greater part of Livermore's valley is of a gravelly soil, and unfit for cultivation.

It is used principally as a cattle rancho, and numerous herds were grazing on different parts of the plain as we passed. This valley is about eleven miles long and six broad. A view of its surface is presented in the annexed wood-cut.



LIVERMORE'S VALLEY.

Several beds of streams intersect it, which in winter may be called rivers, but in summer are perfectly dry. The banks of these are well timbered with cotton-wood and oak, but elsewhere no timber is to be seen. Springs abound at the base of the hills. The waters of this valley accumulate at its western end, forming a lake, from which the water, after flowing through a cañon in the hills, finds its way to San Francisco bay.

LIVERMORE'S PASS.

On the afternoon of July 13 we reached Livermore's house, and encamped at a spring about a mile in its rear, and nearly four miles from the entrance of the pass. Here I determined to stop a sufficient length of time to enable me to make a survey of the pass, in which is the wagon-road usually travelled by those going from San José to the lower San Joaquin valley; and for this reason this pass is much better known than several others lying a little to the south of it. There is, however, good cause for supposing that some of these other passes are better adapted for a railroad than the one known as Livermore's. The hills here are destitute of

timber, and in the spring covered with a luxuriant growth of wild oats. As the season advances, the rain ceases, and the burning sun converts the once green hills into barren-looking mounds. These hills are rounded, and so symmetrical as to give them an artificial appearance.

The three following days were consumed in making a survey of the pass. The spring-wagon was taken to carry the odometer, and the courses were taken with a prismatic compass, on a small tripod, while at every prominent point a reading of the barometer was taken. We found the entrance to the pass to be 481 feet above the level of the sea, and its summit 686 feet, while the altitude of the eastern base of the hills was but 89 feet. This gave a grade of about 60 feet in ascending from the west, and 87 feet in descending towards the east. There would be little difficulty in winding, and thus increasing this distance, to reduce those grades, should it be desirable. Upon reaching the summit, the wagon-road does not at once cross and commence the descent, but continues to ascend more than 200 feet more, in order to find better ground for wheeled vehicles. If it were desired to construct a railroad over these hills, I have little doubt that a proper examination would result in the discovery of much better places than this pass, although this is determined to be practicable. The rounded hills interlocking, cause the road to be exceedingly tortuous, and it would require a great deal of excavation and embankment to make curves with a sufficiently large radius.

SAN JOAQUIN VALLEY.

On the 17th we left camp early, and went through the pass with the wagons without much difficulty, and camped at the eastern base of the hills, near a solitary house, which is known as Elkhorn post office. From here we had, to the east, the broad expanse of the San Joaquin valley. The river had overflowed its banks, and the valley was one vast sheet of water, from 25 to 30 miles broad, and approaching within four to five miles of the hills. It had been my intention to cross at the lower ferry and follow up the eastern side of the valley; but this was evidently impossible. The first point on the river which presents banks high enough to prevent an overflow is at Grayson, one of the cities of California, which looks very well on paper, but in which there are but two houses at present. It is two or three miles above the mouth of the Tuolumne river, the principal branch of the San Joaquin, and 27 miles southeast of Elkhorn. About a mile above Grayson a ferry has been established, and here we crossed with our teams and animals, (the work of a whole day,) and camped on the Tuolumne, five or six miles from its mouth.

This river, as indeed are all the rivers flowing into the San Joaquin and the lakes, is fringed with trees. In the summer and autumn, when the water is low, these trees are 20 and 30 feet above the river; but in the spring, when the snow melts, the waters rise very rapidly, and often overflow their roots. Extensive side-channels or "sloughs" are thus formed, and these are most numerous near the mouths of the streams. On this account permanent bridges crossing these streams must be much longer than otherwise. There is no difficulty in finding good points for crossing. The Tuolumne would require a bridge from 200 to 300 feet. We followed up this river for 25 miles, when we struck the ordinary wagon-road, and thence proceeded to Fort Miller, a military post on the San Joaquin, in the foot-hills of the Sierra Nevada. As there is no doubt of the practicability of constructing a railroad to the extreme head of the Tulare valley, I do not think it expedient to enter into a detailed description of this vast plain, but refer to the few remarks at the commencement of this report, and the maps and tables accompanying it, for such geographical and topographical information as may be required.

Chs Koppel

T. Sinclair's lith. Phila

ENTRANCE OF LIVERMORE'S PASS

PLATE III.

From a sketch by C. Koppel

Lith. by A. Hoen & Co. Balto

PLAIN BETWEEN THE SAN JOAQUIN AND KING'S RIVERS

From a sketch by Chs Koppel

PLAIN BETWEEN KAH-WEE-YA AND KINGS RIVER.

The plains between the streams are destitute of foliage, and the soil generally gravelly and poor. It is very dry in summer from the effects of the sun, but in winter it absorbs vast quantities of water, and becomes so soft as often to prevent the passage of vehicles, or even animals.

We were obliged to stay at Fort Miller a week, to have our wagons repaired, and to have many of our mules shod, there not having been time to do this at Benicia. We also here obtained an additional supply of provisions and quartermaster's stores. This post is distant, by the way we travelled, 174 miles from Martinez.

TULARE VALLEY.

Having completed all our arrangements on Saturday, July 30, the next day we bid good-bye to our friends at the fort, and long before daylight were on the road, to advance to King's river, over a dry, barren plain, on which not a drop of water was to be found; and the heat of the sun may be imagined, knowing the fact that the thermometer had stood the day previous at Fort Miller at 115° Fahrenheit in the shade. We had the pleasure of meeting on the road Mr. Senator Gwin, returning from a trip to the Tejon Pass, where he had been to examine personally the adaptation of the country for a railroad. King's river, called on many maps Lake Fork, is a deep and rapid stream, about eighty yards wide. When it first emerges from the mountains it divides itself into seven or eight different streams, which reunite near the place we struck it. From there to its delta near the lake it has only one bed. An American had established a ferry about twelve miles below our camp, and having marched there, we occupied the rest of the day in crossing.

The next stream we came to was the Pi-pi-yu-na, or Kah-wée-ya, and very commonly known as the Four Creeks. Immediately upon leaving the mountains, like King's river, it divides itself into several streams; but, unlike those of that river, they do not unite, but continue to diverge, forming a delta, whose base is over fifteen miles long. The whole of this delta is covered with a luxuriant growth of oak. The soil is rich, producing spontaneously many kinds of grasses. The contrast between this beautifully-green spot and the arid plains on each side is very striking. It is well shown by Plates IV and V, which are views taken from the same point. Plate IV is a view looking eastward towards the Sierra Nevada, whose snow-capped summits are seen in the distance, and the bottom land of the river, covered with timber, is seen in the foreground. Plate V is a view in the opposite direction, and shows the arid plains between the Kah-wée-ya and King's river.

The Kah-wée-ya is divided into four small streams where the road crosses, the extreme ones being four and a half miles apart. Two of them, though narrow, are quite deep, and required bridging.

This delta is fast filling up with American settlers. Already on the second creek is the town of Woodville, which, however, when we passed, contained but one house. Here I was fortunate enough to meet with Mr. Alexander Godey, a most excellent and experienced mountaineer, and who knew more, perhaps, about the mountain passes in the Sierra Nevada—which I was about to examine—than any one in the country. He had just returned from the Tejon, where he had been with the hope of meeting Mr. Edward Beale, superintendent of Indian affairs, who had been expected for some weeks. I proposed to him to accompany me, and he finally agreed, with the understanding that he was to be allowed to leave as soon as Mr. Beale should arrive.

Leaving Woodville, we continued in a southeast direction, travelling for seventy miles near the base of the mountains, and crossing numerous small streams, or dry beds of streams, when

we came, August 6, to O-co-ya, or Pose creek, seven miles north of Kern river. We learned from Godey and others that on Kern river there was no grass, while here we had fine grass in abundance. We were now near the head of the valley, and the passes to be examined, and I therefore determined to select this point for a depot camp, from which future operations would be conducted.

DEPOT CAMP—FUTURE PLANS.

O-co-ya creek, at this season, is not here a running stream, but water in holes is found in abundance, and is very good. I am told it never fails entirely.

My plan was to go with a small party first to Walker's Pass, and having examined it from base to base, to return to the summit, and from thence follow, as closely as the configuration of the country would permit, the water-shed, or "backbone" of the mountains, till I had reached the point where the Sierra and Coast range unite. I would by this means be certain of seeing every depression in the mountains. I would then endeavor to ascertain the accessibility of these depressions from either base. By this plan I supposed I would gain a good knowledge of the general character of the Sierra in this vicinity, and would be able to select judiciously the best passes for minute survey.

The question as to the comparative value of a barometric profile, as compared with one made from measurements with the level, was one that had never been answered definitely. We knew that the results would not coincide exactly, but the limit of probable error had not been determined. If, therefore, I should survey one or more of the passes with both instruments, and, comparing the results, find that they agreed closely, it would be presumptive evidence that those profiles, made from barometric measurements alone, would agree equally as close; whereas, if a great disagreement was found, it would shew that the barometric profiles were not reliable. For these reasons I resolved to run a line of levels, from base to base of the Sierra, through one or more passes, as the results of the preliminary reconnaissance might determine. I was aware that this would occupy several weeks; but as the bearing of the result would not be upon the one pass only, but upon every one examined during the survey, and perhaps upon the barometric profiles of the other parties whose extended lines did not permit them to use the level, I believed the time could not be devoted to a better object.

While the preliminary examination was going on, the wagon-train was to return empty to Fort Miller, to obtain a further supply of provisions and barley, and Lieutenant Stoneman, with that portion of the escort not otherwise engaged, was to remain in Depot camp to guard the stores and other property left there.

On the morning of August 10, the wagon-train started from Fort Miller; and I, accompanied by Lieutenant Parke, Mr. Smith, civil engineer, Mr. Preuss, draughtsman, Mr. Godey, as guide, and five men of my party, started for the passes in the mountains. We had an escort of a corporal and nine men. We carried with us two barometers, besides the aneroid, a sextant, and the other usual instruments for a surveying party. In giving the result of the reconnaissance, I will, for more convenient reference, separate it under different heads, according to the pass to which the particular part may refer.

WALKER'S PASS.

Upon leaving camp we followed up Pose creek till it took a bend coming from the northeast, when we left it and took up a dry branch, with here and there a spring, our general course

being a little north of east. We could see the open valley of Kern river to the south and southwest. Higher up, this river cañons; and it was to avoid this cañon that we were obliged to keep the ridge, where there is a good pack-trail, but impracticable for wagons. We camped in a little hollow in the mountain, and the barometer indicated the altitude above Depot camp to be 3,400 feet. As we had descended somewhat to find a camping-place, the highest point we passed over must have been over 4,000 feet above that camp, or nearly 5,000 feet above the level of the sea. Directly opposite us, on the other side of the river, was a mountain which we called Cañon mountain, still higher than the one we were on; and these two mountains, approaching each other with precipitous side-slopes, formed the cañon above mentioned.

The next day, after ascending a short distance, we began to descend. We could see the river far below us, white with foam, looking like a thread of silver as it dashed among the rocks with a very rapid current. There was the appearance of a large valley at the base of the mountain. Godey told us that the river there received a tributary, and that it was near the head of that stream that we should find Walker's Pass. The descent was very steep; so much so that in many places it was dangerous to ride, and it was more easy to slide down than to walk. We arrived on the banks of the river, at the base of the hill, just in time to allow me to get a series of circummeridian altitudes of the sun, about half a mile below the mouth of the branch.

The river was very rapid, and apparently deep. We tried to find a ford in several places, but did not succeed till we had gone up stream three miles; and here the water came nearly up to the mules' backs. To keep our packs dry we had to have them carried across by the men. After crossing, we went up the valley of the creek for four or five miles, and made a camp in fine grass on its banks. The valley is from one to three miles wide, with a poor soil, except in the bottoms near the creek, where the grass grows luxuriantly. Following up the valley, which averaged more than a mile in width, with a gentle ascent, gradually increasing all the way, we found, about twelve miles from the mouth of the creek, a small branch coming in from the south, now dry, but having apparently a long and wide valley. Five miles further, the creek, now a small brook, came from the mountains to the north, while from the southwest there was an open valley from a quarter to half a mile in width. This valley we followed up; and having arrived within a mile and a half of the summit, we were fortunate enough to find a fine spring and plenty of coarse grass. Here we made our camp; and, it being early in the afternoon, I rode up to the summit, where I had a fine view of the basin. There appeared to the eastward a strip, twenty or thirty miles wide, of unbroken ground; and beyond this the view was limited by masses of mountains. The pass is nowhere less than a quarter of a mile wide, and the ascent and descent both gradual. In fact, it is an excellent natural wagon-road. The mountains on either side are composed mostly of granite, and are rough and precipitous.

There were quite a number of Indians, both on the creek and at the spring near our camp. At first they fled, but soon gained confidence, and came into camp. They seemed at this season of the year to be principally employed in collecting a kind of bulrush or cane, upon the leaves of which is found a substance very like sugar, which to them is a not unimportant article of food. They cut the cane and spread it in the sun to dry, and afterwards, by threshing, separate the sugar from the leaf. The cane itself had no sweet taste. As the creek had no name that I knew of, I endeavored to ascertain its Indian name, and found it to be Chay-o-poo-ya-päh—the accent strong on the last syllable. This name I have adopted on the map. I understand it to mean the creek of the bulrushes.

The following day was occupied in examining the pass fully, and obtaining data for making

a barometric profile. We descended from the summit more than eight miles, and found the belt of unbroken ground to extend as far as we could see along the base of the mountains, in both directions. I will now state the results of the subsequent calculations of our observations, from which an opinion of the practicability of the pass for railroad purposes may be formed.

Starting from Kern river, at the m uth of Chay-o-poo-ya-päh, and ascending to the point where the latter comes from the mountains, a distance of 17 miles, we have a gentle ascent, viz: $5\frac{3}{4}$ miles on a grade of 13 feet per mile, $6\frac{1}{4}$ miles of 29 feet per mile, and the remaining 5 miles at 17 feet per mile. From here over the summit to the point we reached in the basin is $16\frac{1}{4}$ miles, and this part may be considered the pass proper. Here the grades are of an entirely different character. We have for the first $6\frac{1}{2}$ miles (which brings us to our camp) an average grade of 272 feet to the mile—less than this at first, but gradually increasing as the summit is approached; from camp to the summit, $1\frac{1}{2}$ mile, at 428 feet per mile; and from the summit to the base of the mountains, $8\frac{1}{4}$ miles, at 265 feet per mile.

These steep grades, for so long a distance, would at once render this pass out of the question, even admitting them to be practicable, unless it can be shown that there is no better one, or that it has a pre-eminently favorable position.

That there are passes with better grades, will appear in t e sequel. As to its position, I consider it one of the worst of all the known passes in the Sierra Nevada. As far as we know the country, (and its general features are well known,) the whole portion east of Walker's Pass, for two or three degrees of longitude, is a mountainous desert, almost destitute of wood, water, and grass. It is universally conceded that any road reaching this pass must have come either from the Vegas de Santa Clara, the Mohave river, or from the south. If coming from the Vegas, in anything like a direct course, the position of the pass would be preferable to one farther south; but this desert would have to be crossed, and the practicability of such a route is still a problem. For any road coming from the Mohave, or from the south, a pass farther south would possess a preferable position.

But suppose a road arrives at Walker's Pass, and, surmounting the obstacles of steep grades, enters the valley of the Chay-o-poo-ya-päh, and follows it down to Kern river; there is, then, no other course of proceeding open but to follow down this river, for the high mountains on each side afford no chance of a passage. The cañon before mentioned is said to be five miles long, and, according to information obtained from the Indians, the precipitous rocks, jutting into the stream first from one bank then from the other, preclude the possibility of even a foot-trail through it. It is probable, also, that here the river is very rapid. The point where we struck the river, near the mouth of Chay-o-poo-ya-päh, according to the barometer, is 2,600 feet above the level of the sea, and Kern lake, at the head of the Tulare valley, is but 400 feet. The distance, as taken from the map, is forty miles. Adding one-fourth for sinuosities, and we have an average grade of forty-four feet to the mile. The course of the stream is southwest, at right angles to the proper direction of a road that is to traverse the Tulare and San Joaquin valleys.

After due consideration of the foregoing facts, I think I am justified in saying that Walker's Pass is badly situated, and impracticable.

But many persons may naturally ask, Is this pass, here described, Walker's Pass? is this the pass which every one, two years ago, admitted to be an excellent one? It is due to me that this question s ould be answered.

Mr. Joseph Walker, from whom Walker's Pass takes its name, is an old mountaineer, and

was, I believe, a trapper in California long before the first exploring parties were sent there. Of the minutiæ of his early history I know but little, but it is not relevant to the subject. He, however, in one of his numerous expeditions, found a very good pass in the Sierra Nevada, which he thought would answer admirably for a wagon-road. This he reported when he was in Missouri, or some one of the (now so-called) Eastern States. In August, 1845, Colonel Frémont started on an expedition to the Pacific, by the way of the headwaters of the Arkansas, White river, Great Salt lake, and Mary's or Humboldt river, and he engaged the services of Walker as guide. Mr. R. Kern, whose lamentable death with Captain Gunnison and party is known to all, was topographer or draughtsman to the expedition, as also was Mr. Charles Preuss. Mr. Alexander Godey, of whom Colonel Frémont speaks in the highest terms, was also of the party. When Colonel Frémont reached the eastern base of the Sierra Nevada, which he did in the vi nity of Walker's lake—say latitude 38° 30′ north—he found that his party would soon be out of provisions. He therefore separated from the main party, and proceeded as rapidly as possible to Sutter's Fort to obtain a supply of live stock, flour, &c., with the understanding that the main party, under Walker and Kern, were to follow southwardly the eastern base of the Sierra till they came to the pass Walker had discovered; and here, in the mountains, on a stream flowing west from the pass, they were to remain in camp till relieved by Colonel Frémont. At this time very little was known of this part of the country. Walker drew a rough sketch of the route to be pursued by Colonel Frémont in order to find his camp. The main point in his instructions was, that he should pass the San Joaquin river and continue on southeasterly till he came to a large stream. This he was to ascend till he found a branch coming in from the east, and in the valley of this branch he would find the camp.

Colonel Frémont succeeded in obtaining the provisions he required, and started in search of Kern and Walker. Following Walker's directions, he crossed the San Joaquin, and farther on came to a large stream answering in every respect the description. It is the one now known as King's river, and called on some of the maps Lake Fork, and is a hundred miles north of the place where Walker was encamped. This stream he ascended, and searched for a long time in a very rugged country, in many places covered with snow, but could find no trace of the party; and, thinking they had gone in to the settlement, he gave up the search and went to Monterey. It is possible (indeed almost certain) that Walker did not know of the existence of King's river when he was directing Colonel Frémont where to find him, for, when he arrived there on his way to Monterey, he mistook it for the San Joaquin.

Walker reached the pass late in December, and, passing the divide, made his camp in the valley of the stream flowing from it. Here he waited till the 18th of January, 1846, when he gave up all hope of seeing Colonel Frémont, and, his provisions being nearly exhausted, he started for the settlement, and subsequently rejoined the Colonel at Monterey.

From these circumstances the pass in which Walker and Kern were encamped was called Walker's Pass; and, as no name was known to Colonel Frémont for the stream which flowed from it, he named it Kern river. This stream was, and is now, known to the native Californians as the Po-sun-co-la, a name doubtless derived from the Indians. When I was at the ordinary crossing-place of the river, and preparing a small raft to cross, three Californians rode up to the opposite bank, and asked, in Spanish, if this was the Po-sun-co-la.

This pass, in which Walker made his camp, is undoubtedly Walker's Pass.

Colonel Frémont, in April of the preceding year, (1844,) had crossed the Sierra about half a

degree south of this pass, and he may subsequently have concluded that the place he crossed was Walker's Pass, though I am not aware that he even so asserted.

In the year 1848 the notes of Colonel Frémont were compiled by order of the Senate. The work was done by Charles Preuss, and Kern's notes of this expedition were used in plotting Walker's Pass on his route of 1845, while Colonel Frémont's notes were used in plotting the pass on his route of 1844. Both trails are marked on the map, and make the matter perfectly clear. The most of these details were obtained from Godey and Preuss, and show conclusively that Colonel Frémont, up to this year, never was at Walker's Pass.

In the spring of this year (1854) he arrived at the eastern base of the Sierra Nevada, probably north of the 37th parallel. Finding it difficult to cross there, he was obliged to skirt along the mountains southwardly, till he came to a fine open pass, of the existence of which he was not previously aware, as the California papers announced it as an important discovery. I have conclusive evidence to show that this was Walker's Pass—the one just described—and of which Colonel Frémont could have known nothing definitely, as he had never been there before.

When it is asserted that *Walker's Pass* is an excellent one, and the person making the assertion refers to an entirely different place, the unintentional inaccuracy of the statement is due entirely to an ignorance of localities, and such ignorance is excusable when the localities are in a country so little known.

HUM-PAH-YA-MUP PASS.

Having completed the examination of Walker's Pass, in order to follow my original intention of tracing the water-shed of the mountains as near as possible, I found it necessary to retrace our steps down the Chay-o-poo-ya-päh for thirteen miles, till we came to the collateral valley before mentioned; for the mountains to the south of the pass were so high and rugged, that the only way to pass them was to turn them. We ascended this valley, which was about two miles wide. At first it was a broad bed of sand, which gradually contracted, and five miles up we found running water. There was an abundance of the bulrush growing here, and a large number of Indians, probably fifty or sixty, engaged in gathering it. They had evidently heard of us from their neighbors, and did not show the least sign of fear; but men, women, and children came flocking around us, evincing much curiosity. We camped among them, and the next morning Godey and myself started to examine the next depression in the mountains south of Walker's Pass. This we found to be about the same altitude as that pass, viz: about 5,300 feet, and the ascent a little steeper. It is not as open as the other, and hence is not as good a natural wagon-road. The average ascent for several miles is 288 feet to the mile. Like Walker's Pass, were the divide once passed, the further difficulty presented in the descent of Kern river is still to be encountered. It is about six miles in rectilinear distance from that pass.

TAH-EE-CHAY-PAH PASS.

Breaking up our camp on Hum-pa-ya-mup creek, we ascended this stream and crossed the divide, when we came upon the waters of a little stream flowing towards the basin. These small streams all have running water near their sources, but invariably become dry after running a few miles. The mountains here are thickly covered with brush; so thick, that, after an ineffectual attempt to proceed, we were obliged to return to the water and make camp, while Godey spent the afternoon in searching for Indian trails. He succeeded in finding one leading

in the direction we wished to go, and the next morning we proceeded onward without difficulty. Our trail led over a series of spurs from the main mountain ridge, which we crossed twice during the day. Our altitude on one of these ridges was 5,500, feet and on our left was a high peak, towering above us from two to three thousand feet more. From this ridge was a steep and continuous descent for eight or nine miles, when we found ourselves in a beautiful prairie, apparently completely surrounded by high mountains, and, as far as the eye could tell, it was a horizontal plain. It was ten miles long, and from three to four broad. We came to an Indian rancheria, where we learned that there was a stream of water and good grass two or three miles further on. We proceeded to the place, and here found an excellent camping ground. This afternoon (August 17) we had a heavy thunder-shower, which lasted between two and three hours, and we all came into camp as wet as if we had been in a river. I could see no appreciable effect from it on the barometer. This is the only shower we had from the time of starting till late in November. There was another rancheria close to the place selected for our camp, and from the Indians we learned that their name for the creek was Tah-ee-chay-pah. It is the one called Pass creek by Colonel Frémont, and is the same one he ascended when he crossed the mountains in 1844. This camp was not removed for three days, the time being occupied in making examinations in the vicinity. We knew that the creek (upon whose headwaters we were encamped) flowed towards the Tulare valley, but we did not know at what point it entered it. We first went down the creek with the barometer, and found it emerged from the mountains about midway between Kern river and the Tejon. We descended the stream for 15½ miles, and found the average descent to be 157 feet. The creek was narrow, and, in many places, the mountains closed in, forming precipitous banks, while in others there was a valley half a mile wide. The hills, in many places, afford side-slopes favorable for making detours to gain distance and decrease the grade. The steepest grade found in any part was for a distance of 1½ mile, where it was at the rate of 192 feet to the mile. Timber was abundant.

From our camp, looking to the east and southeast, the hills (which we took to be the main ridge of the Sierra Nevada) looked quite low, and there seemed to be several depressions, which led us to hope we should find one, at least, favorable for railroad purposes. Being satisfied with regard to the creek flowing westward, we commenced an examination of the approaches from the Great Basin. We went first to a gap in the hills nearly east of our camp, and found it to present steep slopes on both sides; but pursuing our examination further, we were agreeably surprised to find that only a mile north of this gap was a break through the hills, through which the waters, collected in the eastern end of the prairie, discharge themselves into the basin; so that, in fact, the water-shed or divide of the Sierra was actually in the prairie itself, and the range of hills, mistaken for the main ridge, was, in fact, only a spur. A small lake-bed covered with an incrustation of salt is immediately at the entrance of this creek, and two miles further down we found springs of fresh water. There was a continuous bed of a stream, now dry, continuing into the basin, and the bases of the hills, on either side, were a quarter of a mile apart. The descent, for the first six miles, from the prairie, was at the rate of less than 80 feet to the mile, and further down it was more gradual. The height of the summit was 4,020 feet, and was the lowest point of the Sierra that I found. Altogether, the position and grades of this pass are more favorable than those of Walker's, and eventually proved to be more favorable than those of any other in the Sierra.

We next proceeded to examine the place where Colonel Frémont passed, and which was pointed out to me by Mr. Preuss, who was with him at the time, and subsequently plotted his notes.

This point was in a southeasterly direction from camp, and was in a much more direct line to the Mohave river than the outlet of the prairie we discovered. In crossing the spur, however, we had to ascend about 600 feet in less than two miles. This point would be far preferable for a wagon road, being much more direct, and the ground, in wet weather, more solid than in the outlet. We ascended a high peak south of this point, and I gained a much better idea of the topography of the country than I had before.

It may be a question whether it would not be expedient to make a tunnel at this point, if a road is to come from the southeast, rather than follow the more circuitous course on a gentle grade. The distance saved would be from 12 to 14 miles. I am inclined to think that both time and expense would be saved by taking the longer route.

THE TEJON.

On the 21st of August we broke up our camp on Tah ee-chay-pah creek, and marched to the Tejon, which is the name given to the extreme southern portion of the Tulare valley lying immediately at the base of the mountains. The word is pronounced as if spelled Tay-hone, the accent being strong on the last syllable. The derivation of the word is uncertain. Whether it is taken from the Spanish word tejon, meaning a badger, or whether it is an Indian word, I am unable to say. The trail which we followed led us for ten miles through a series of prairies

TEJON INDIANS.

similar to, but smaller than the one we had left. We at first ascended slightly, till we came to a marshy place, from which flowed two little streams, the one to the north into Tah-ee-chay-pah

ENTRANCE OF THE TEJON PASS, AND A PORTION OF THE TEJON.

creek, the other westwardly towards the Tejon. The western extremity of the last of these prairies was only 240 feet lower than the water-shed in the Tah-ee-chay-pah prairie, and the descent to the Tejon was made in less than five miles. The prairie abounded in springs, and the water, co ecting at its western extremity, flowed through a precipitous ravine to the prairie. This ravine ' examined with care, and subsequently went through it with the level; for I thought, if the calculations of the observations taken on Tah-ee-chay-pah creek should prove the grade down that creek to be too steep for a railroad, and it became necessary to resort to inclined planes with stationary engines, that this would be an excellent location for such constructions. I found the descent very steep, in some places over a thousand feet to the mile, and the average for a mile and a quarter was over 900 feet.

The Tejon is really a beautiful place. It receives several small streams, all of which sink shortly after leaving the mountains; but the ground being moist, produces fine groves of oak, and abundance of grass, and the green and fresh appearance of the spot presents a striking contrast to the parched and barren plain north of it.

Plate VI represents a part of the Tejon, with its timber, in which our camp was made. The gap in the mountains in the background is the entrance to the pass. The Indians here are semi-civilized; many of them speak Spanish; and they cultivate melons, pumpkins, and a little corn.

Three white men had also squatted here. They had made no improvement, however, but were waiting till they could perfect a title to the land. Northwest of the Tejon are two small lakes, known as Kern and Buena Vista lakes. The former receives the waters of Kern river, and discharges itself into the latter. These lakes are doubtless connected with the larger Tulare lakes. In fact, the middle of the valley from these lakes northward, to within 10 miles of the San Joaquin river, is, where it is not covered with water, a marsh, and is only passable during the dry season. Kern lake may properly be considered the head of the Tulare valley, and from it the ground slopes rapidly to the base of the mountains, where it has an altitude of from 1,500 to 2,000 feet above tide. I sent a barometer to the lake, and ascertained its altitude to be 398 feet.

Near the eastern extremity of the Tejon is a break in the mountains, known as the Tejon Pass. Through this break a wagon-road has been made leading to Los Angeles, and it is one of the worst roads I ever saw. This pass had been much and favorably spoken of as a railroad pass. About 15 miles to the westward is another pass, known as the Cañada de las Uvas, through which is a pack-trail, also leading to Los Angeles. We were assured by all, that between the two the mountains were much higher than at either of them. I therefore determined to go through the Cañada, and afterwards skirting the southeastern base of the Sierra, enter the Tejon Pass, and, following the wagon-road through it, return to the Tejon.

The Cañada de las Uvas appeared to the eye to be an excellent pass, and the barometer indicated its altitude to be much less than most of those previously examined. The Tejon Pass is a peculiar one. The altitude is quite great; but the ascent and descent appeared to be gentle, except very near the summit. It was hence supposed that, by means of a tunnel, the pass might be found to be a good one. From these considerations, and from the fact that the Tejon was confidently asserted to be an excellent railroad pass, I selected these two points for my experiment with the spirit-level, to get accurate profiles, and test the value of those from observations with the barometer.

The Cañada was supposed to be the last pass in the Sierra, as at or near this point it united

with the Coast range. Still some vague Indian reports led me to suppose there might be one further west; and to be perfectly sure of having examined all that existed, I procured an Indian guide, and, leaving the Tejon, followed the base of the mountains westward for about 10 miles, when we came to a small stream. This the Indian assured us was the place, and we accordingly ascended it. We found the road very rocky, the ascent steep, and the altitude of the summit high. Upon descending from the summit six miles, we found ourselves near the summit of the Cañada de las Uvas. This at once proved the latter pass far superior.

Having thus most happily concluded the reconnaissance, during which data for the construction of six barometric profiles had been obtained, and the almost positive assurance that there existed no pass in the Sierra, south of Walker's, but those I had examined, I returned to the Depot camp on O-co-ya or Pose creek, where I arrived on the 29th of August, having been absent just twenty days—the exact time named at my departure. By a rather singular coincidence, the wagons arrived from Fort Miller on the same day, filled with the stores we required for future operations. Everybody was well in camp, suffering only from a desire for a more active life.

On the 1st of September we broke up camp, and marched to Kern river, where the rest of the day was employed in crossing the stores on a raft. Leaving this river for the Tejon, we went, in as direct a line as possible, across the open plain, our train of ten heavy wagons breaking down the bushes, and making a well-marked trail, six or eight miles shorter than the old trail, which followed the foot of the hills, and which has since been abandoned by the emigrants, they giving the preference to the one we made. Arriving at the Tejon, we selected a place for a depot camp, in a beautiful grove of oaks, surrounded by abundant grass, and near to the Tejon creek, and commenced our operations for surveying with the spirit-level. I detached Lieutenant Parke with instructions to make a hasty reconnaissance of the country in the direction of Los Angeles and its vicinity, hoping the information he would gain would be very valuable in deciding upon the most desirable course to be pursued in prosecution of the survey, as ultimately proved to be the case. We found Mr. Ed. Beale, superintendent of Indian affairs, at the Tejon, he having just arrived, after a long and arduous journey across the plains. A few days afterwards he selected this point for an Indian reservation.

TEJON PASS.

The surveying party, composed of Mr. Smith, Mr. Preuss, and myself, with the necessary rod-men, chain-men, &c., commenced, September 5, the survey of the Tejon Pass, the starting-point being the stationary barometer in camp, which had been placed in a brush-house open at the sides to admit freely the air, and was to be observed every three hours during the day. Mr. Smith took charge of the levelling party, while I, with Mr. Preuss, were working with chain, compass, and the barometer. Mr. Preuss made sketches of the hills and ravines on either side, so that his notes, in connexion with my compass bearings, would afford the means of making an accurate topographical map of the pass. The barometer was read, as a general rule, every quarter of a mile; but where any decided change in the uniformity of the inclination was perceived, that place was always made a barometric station. Mr. Blake made geological examinations, and connected them with the stations of the survey.

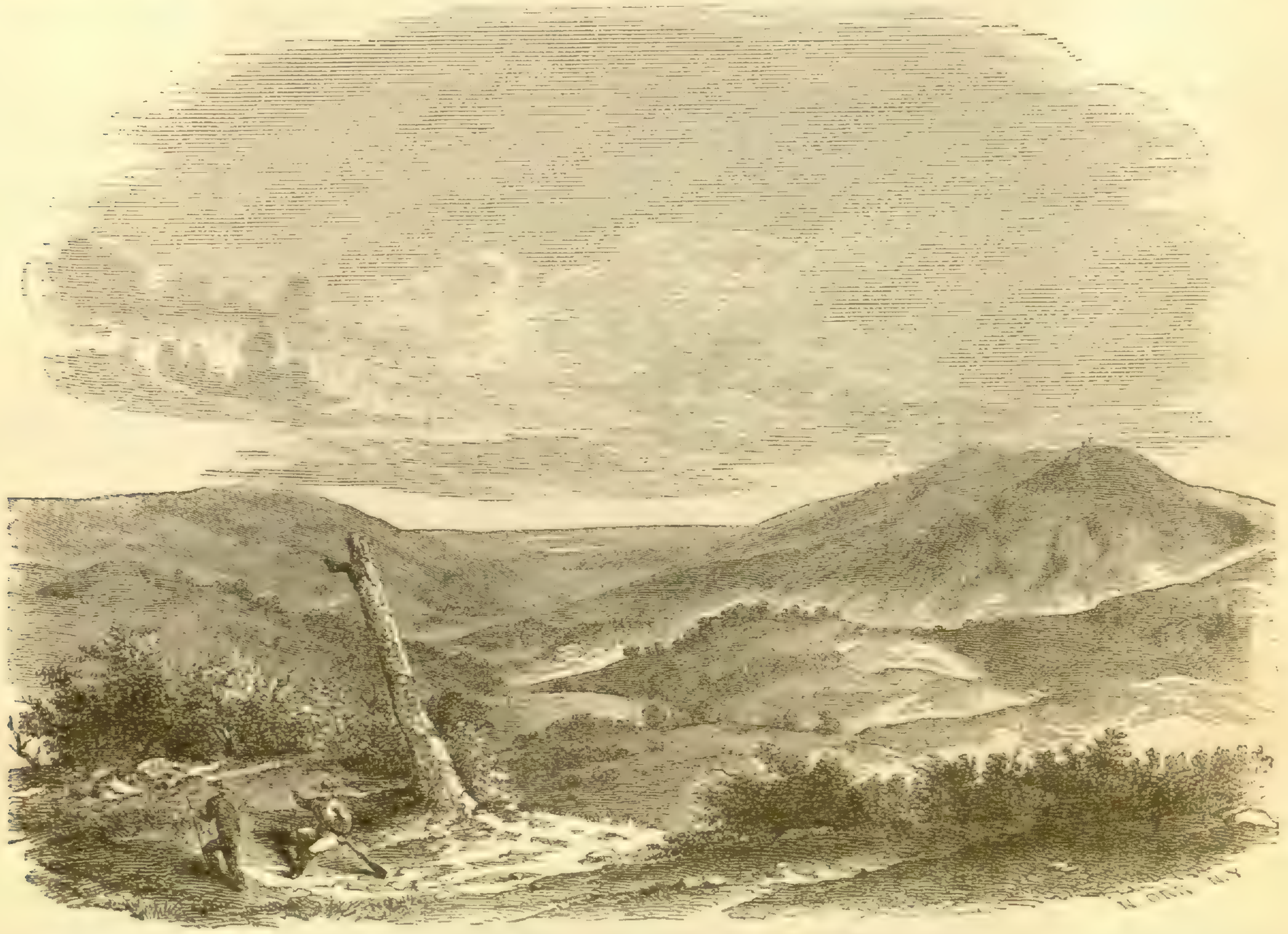
On the 18th September we returned to Depot camp, having completed the survey of the pass, and also of the ravine before mentioned, leading from the mountain prairie into the Tejon.

I will now give the results of the survey, merely mentioning here that the profile, as determined by the spirit-level and by the barometer, agreed remarkably well, seldom differing fifty feet, even with the ordinary mode of calculation, which is much less refined than if the minute corrections had been applied. This subject will be elaborately discussed in another place, and hence it is thought sufficient to mention here the simple fact, without further remark.

From the Depot camp to the point where the Tejon creek debouched from the mountains was a distance of two and eight-tenths miles, over unbroken ground. To the eye this appeared very slightly deviating from horizontality. The level showed a difference of altitude of 483 feet, giving a grade of 173 feet to the mile. The barometer made the difference of level 15 feet greater. I was surprised at this result, which taught that very erroneous impressions must generally be conceived with regard to differences of level if the eye alone is trusted to.

From the entrance of the pass to the point where the precipitous ascent before mentioned commences, and where a tunnel must commence, is a distance of eleven and four-tenths miles, and the difference of altitude was found to be 2,665 feet, giving an average grade of 234 feet to the mile, the minimum grade between any two stations being 150 feet per mile for half a mile, and the maximum being 383 feet per mile for nine-tenths of a mile. The barometer made the total difference of level 44 feet less.

The annexed sketch was taken from the crest, and the observer is supposed to be looking westward, through the valley of the pass, to the plains of the Tulare valley.



TULARE VALLEY, FROM THE SUMMIT OF TEJON PASS.

From this point, going eastward, we have an ascending grade of 2,207 feet to the mile, to the crest; then a descending grade of 728 feet, to a point on the eastern slope where the descent

becomes less and more uniform, and which corresponds with the point above described, at the western base of this wedge-like summit. The horizontal distance between these two points is about 1.15 mile, which is the distance it would be necessary to tunnel.

From here to the point in the Great Basin where we left off levelling, the distance was 6.4 miles, at an average grade of 205 feet to the mile, the difference of level being 1,308 feet. The maximum grade between any two stations was 267 feet per mile for about half a mile, and the minimum 138 feet for nearly the same distance. The barometer made the difference of level between the two points 28 feet less.

SIDE RAVINE IN THE TEJON PASS.

The eastern terminus of the line was 3,388 feet above the sea, and was on the edge of the Great Basin. From here the ground assumes an unbroken appearance in the direction of a large dry lake-bed, about 25 miles distant and 1,000 feet lower. As this lake has probably no discharge, and is fed only by the drainage of the surrounding mountains after heavy rains, its altitude, 2,388 feet, may be considered that of the lowest part of this, one of those many subor-

dinate basins which collectively compose that vast tract of country which has been named the *Great Basin.* As Kern lake is 398 feet above the sea, it appears that in this part of the range the descent from the summit of the Sierra to the head of the Tulare valley is nearly 3,000 feet more than the descent from the same point to the rim of the Basin.

The crest of the Tejon Pass is 5,285 feet above the level of the sea.

The grades in the Tejon Pass were much greater than I had anticipated, and, owing to the nature of the ridges, it is not possible to reduce them by side-cuttings. These difficulties consist in steep and rugged ravines, which furrow the mountains on each side and descend to the valley of the pass.

A view of one of these side-ravines from the trail is given in wood-cut on page 34.

I think the difficulties presented by the grades, taken in connexion with the tunnel that would be required, render this pass unfit for railroad purposes.

CAÑADA DE LAS UVAS.

Before commencing the survey of this pass, a line nearly straight was run across the Tejon to its entrance, to ascertain the absolute height above the sea of that point, assuming that the altitude of the Depot camp had been correctly ascertained. We found its altitude to be 193 feet above camp, or 1,640 feet above the sea.

TULARE VALLEY, AND ENTRANCE OF THE CAÑADA DE LAS UVAS.

This pass possesses some peculiarities worthy of note, for the line of survey may be said to go around the end of the Sierra Nevada, the pass being at the junction of the Sierra Nevada

with the Coast range. The ridges of the latter curve around the southern end of the Tulare valley and form its boundary. At the foot of these ridges, and on the south side of the entrance to the pass, there are low rounded hills, much cut up by ravines, and often presenting precipitous banks, apparently of clay. (See Plate VII.) Mr. Blake describes these hills as of sedimentary origin, and of the age of the Tertiary.[1] After entering the pass, we ascend a stream flowing from it into the Tejon, fed by springs situated about half way to the summit.

In the ravine of this brook the bases of the mountains approach closely, forming but a narrow valley; but still ascending beyond the springs, the valley opens out to a plain from one-half to three-quarters of a mile in width, and the ascent is less steep. When quite near the summit, the ascent becomes more abrupt for a short distance. Descending from this divide, we come upon waters flowing into the Santa Clara river, and thence into the Pacific. Some distance beyond we come to another small divide, descending from the summit of which we are upon the waters flowing into the Basin.

From a short distance beyond the summit to the Great Basin, the valley of the pass is wide and bounded by low hills. Near our last camp in the pass the broad expanse of the Basin was visible, broken here and there by isolated ridges of barren rocks.

From the western entrance of the pass to the springs at the source of the brook, a distance of five and a quarter miles, the grades are quite steep, averaging 302 feet to the mile, the maximum being 348 feet, and the minimum 229 feet. From the springs to near the summit, the average grades are 121 feet to the mile, while at the summit itself there is for half a mile an ascent of 339 feet per mile, and for three-quarters of a mile a descent at the rate of 441 feet per mile. No difficulty is then experienced till we arrive at the second divide, which separates the waters flowing towards the Pacific from those flowing towards the Basin. Here we had a descent for half a mile at the rate of 357 feet per mile, after which the descent is gradual to the Basin.

The main difficulty in this pass is the very steep grade in the bed of the brook. The hills on either side are cut up by deep ravines—so much so as to prevent recourse to side-cuttings. The two divides are easily passed by tunnels from a half to one and a quarter mile in length.

There is a good wagon-road through this pass; and I learn that, since our survey, a military post has been established at or near the springs.

GENERAL REMARKS ON THE PASSES OF THE SIERRA NEVADA.

In the foregoing general description of the most important of the passes examined in the Sierra, I have spoken of only the most important features of each pass, giving their grades, and endeavoring to explain the position and peculiarities of each, so that a general comparison may be made. This was all that was necessary, as the accompanying tables give in a concise form full and minute information, as also the data from which this information was obtained; and these tables, in connexion with the maps and profiles and the sketches, form a complete description of the passes. I think the facts which have been brought forward warrant the following conclusion:

Of the five principal passes described, there are two which are pre-eminently superior to the others, viz: the Tah-ee-chay-pah Pass and the Cañada de las Uvas. As far as the situation of these passes is concerned, neither has the advantage if the road comes from the Mohave or the mouth of the Gila; for, taking a point on the map near which such a road must pass, and

[1] Vide Report upon the Geology of the Expedition.

MOUNTAINS NEAR THE ENTRANCE OF THE CANADA DE LAS UVAS

THE GREAT BASIN FROM THE CAÑADA DE LAS UVAS WITH LOST MOUNTAINS IN THE DISTANCE.

LOST MOUNTAINS IN THE GREAT BASIN

measuring from this point the sinuous course through each pass to the probable crossing of Kern river, it is found that the two routes are almost exactly the same in length. Water is equally abundant in each, but timber abounds most in Tah-ee-chay-pah. But the main point of comparison is the grades. In Tah-ee-chay-pah we have 157 feet to the mile for fifteen miles; in the Cañada we have 302 feet for five miles and two tunnels. I imagine, from the little statistical information that I have been able to obtain, that this last grade, though perhaps not positively impracticable for locomotion, would present such serious difficulties that the Tah-ee-chay-pah Pass would be considered by railroad engineers as decidedly the preferable.

THE GREAT BASIN.

On the 5th of October, the survey of the Cañada being completed, we returned to Depot camp. Lieutenant Parke had returned some days previously, and had assisted me in the field-work in the Cañada. His hasty reconnaissance proved very useful, having gained a general idea of the country; and also, from information gained in Los Angeles, he had visited a pass in the Coast range east of that pueblo, situated between the two high mountains of San Bernardino and San Gorgonio, which presented a very favorable appearance. This pass was little known, and had never been considered in connexion with a railroad.

Having concluded the survey of the passes in the Sierra Nevada, my instructions were to ascertain the most direct practicable railroad route to the mouth of the Gila. The direction of the mouth of the Gila from these passes is southeast, and the intermediate country had been represented as a desert. Rumors of parties having attempted to cross it and never having been heard of were common, but no one could be found who professed to have any personal knowledge of it. We knew, however, that the direct route between the two points must cross the Mohave river, distant, in a direct line, about one and a half degree.

I considered it important to examine this district, and also to examine the passes in the Coast range. To accomplish both objects, I determined to go out into the Basin, till I arrived midway between the Sierra and the Mohave, and then, returning, strike over to the mountains. After arriving on the Mohave I could from there come towards the Sierra, and connect with my former line. This plan being adopted, Lieutenant Stoneman, with the escort and wagon-train, left the Tejon, and passing through the Cañada de las Uvas, (where we had made a wagon-road,) followed the base of the Coast range, and camped near the pass of San Francisquito. Lieutenant Parke, with a small party, was sent to the northward in the Sierra, to obtain information required to complete the general map of the passes, and Mr. Blake and myself started to make an examination of the Basin. From the summit of the Sierra, in the Tejon Pass, we had an extended view, which gave a good idea of the formation of the country towards the east and southeast. From the base of the Coast range northward is a belt of undulating land, from 15 to 20 miles wide, and unbroken by any peaks. North of this belt is a system of isolated peaks and short ridges, known as lost mountains, and which, as they extend north and east, increase in height and become worthy of the name of mountain ranges.—(See Plate IX.) These ranges often enclose extensive areas which are destitute of peaks, and in the lowest part, where the water accumulates after heavy rains, is a lake-bed, without water in the dry season.

Having gone through the Tejon Pass, we took our course for the nearest of the lost hills, distant from the base of the Sierra about ten miles. Here we were rather surprised to find several springs of fresh water. These springs formed little streams, running from ten to fifty yards, and then disappearing in the dry soil. Continuing onward in nearly an easterly direc-

tion for about ten miles, skirting the base of a chain of lost hills, which were about 600 feet high, we came to another spring, and a few miles beyond we found a third. We ascended several of the hills to get views of the surrounding country; and finally, after having gone about thirty miles east of the base of the Sierra Nevada, we turned back and rejoined Lieutenant Stoneman in camp.

Subsequently, I came westward from the Mohave river to near the place where we turned back, and found the country presented the same characters, except that no more water was discovered. Independent of the lost hills, the country is a system of inclined plains or slopes; and although there is no serious topographical impediment to the construction of a railroad through it, the grades would often approach 100 feet to the mile. There is no timber, the surface being generally bare, or covered with sage bushes, grease-wood, yucca trees, &c. Mr. Blake confidently expresses the opinion that water can be obtained by boring.

SAN FRANCISQUITO PASS.

Lieutenant Stoneman's camp was near the entrance to the San Francisquito Pass, a pass through which the wagon-road from the Tejon descends from the summit of the Coast range to the Santa Clara valley. He had found no difficulty in conducting the wagon-train through the Cañada de las Uvas, and along the base of the mountains to camp, finding plenty of grass and

LAKE ELIZABETH, SAN FRANCISQUITO PASS.

water at short intervals. I made a survey of the San Francisquito Pass with odometer and barometer, and found it very difficult for railroad purposes, there being a grade of 457 feet for a mile, and over 330 for two miles. The wagon-road passes along and in the bed of a mountain

stream, in many places passing through rocky cañons, where expensive side-cuttings would be necessary. For these reasons I considered this pass as of no importance.

The approach to this pass from the Great Basin, by the wagon-road, is over an outlying ridge, which extends parallel with the main divide, and thus forms a long narrow valley. This valley is occupied by a chain of small lakes, which are bordered by a luxuriant growth of grass.

NEW PASS.

Returning to camp with the intention of advancing to the Mohave river, I was induced by Lieutenant Stoneman's report to ascend a high mountain near camp, from which a fine view of the Santa Clara valley could be obtained; and for this purpose the camp remained in the same place another day. The mountain is the one named on the map Stoneman's mountain, and we found it by aneroid measurement to be 6,000 feet high. From this great elevation we had a very extended view. In a westerly direction we saw the valley of the Santa Clara spread at our feet, the many low hills of that valley giving it almost the appearance of a plain. On the north of the valley was the Coast range; on the south a branch range from the latter known as the Susannah range; while in the valley between, a branch of the Santa Clara was traced, winding its course towards the sea. On the northwest was the Sierra, and on the northeast the Great Basin. Many bearings were taken which afterwards proved useful in plotting the general map.

ENTRANCE OF NEW PASS.

It was proposed to descend the mountain on the side opposite to that we ascended, and to return to camp by going around its southern base. This plan was adopted, and by doing this

we reached, in an open spot, the branch of the river. Following this branch to its source, we were quite surprised to find the depression in the mountains here very low, and the pass, thus found, to be open, and apparently of quite gentle and gradual acclivity. As the existence of this pass was supposed previously to be unknown, I named it New Pass; and though not surveyed till some time subsequent, I will now describe it.

From an accessible point in the Great Basin, nearly eight miles from the divide, the survey commenced, and followed the course of a long open valley leading to the crest. This valley is represented in the annexed wood-cut; the crest or divide is not, however, visible, being between the ridges at the extreme right of the picture.

From the point in the Basin at which the survey commenced until we arrived within a mile and a third of the crest, the grades were below 50 feet. Here we found half a mile at 218 feet, and four-fifths of a mile at 240 feet per mile. These grades can easily be reduced by either excavation or winding to gain distance. Commencing the descent we have 77 feet for $1\frac{8}{10}$ mile, on an almost perfect inclined plane; $3\frac{5}{8}$ miles at 105 feet; and all the rest of the descent far below 80 feet per mile—the greatest being 78 feet for $1\frac{3}{8}$ mile. I may safely say that the descent in this pass can be made without having it at any point a grade as great as a hundred feet. The survey was made with odometer and barometer, and there was no obstruction for the wagon, except for a short distance, occasioned by trees. This pass leads into the Santa Clara valley, near where the wagon-road through the San Francisquito Pass enters it, from which point there is no obstruction to the ocean. I believe this was the first time a wagon had ever been taken through this pass.

Returning from Stoneman's mountain, we continued our route with the train for the Mohave. We were obliged to skirt the base of the mountains to find grass and water, neither being known to exist in the Basin. We found several springs, but finally, after a long march, camped on a bold stream which was a river in the foot-hills, but sank immediately upon reaching the Basin. It is marked on Preuss' map from the surveys of Colonel Frémont; but as we knew no name for it, we called it Johnson's river, after the soldier who found it for us.

The next day our march was very slow and fatiguing to the animals, as the country was filled with yucca trees and bushes, and no road had been broken. Fortunately, about dark we came to a small stream, where our thirsty mules obtained water. Had it not been for this, I think many would have given out. We stopped here a few hours to allow them to rest and eat a little barley that we had saved, and also to get supper for ourselves. Then travelling all night, we reached the Mohave the next afternoon. It was a great relief to all when we struck the "old Spanish trail," for then, the road having been broken, we had no more bushes to contend with. We made a depot camp where that trail strikes the river, October 19, 1853.

So far we had succeeded in progressing towards the mouth of the Gila, but we were by no means sanguine of future success. The country we had passed over from the passes in the Sierra, though very trying to us, presented no impediment to the construction of a railroad, water being obtained by digging, and the total right-line distance about 150 miles. But there were unknown mountains to be examined and crossed before we would be at our destination.

MOHAVE RIVER.

The three days subsequent to our arrival on the Mohave were spent in examining the country in different directions, so as to form a proper plan for our future movements. Every peak in the vicinity which seemed likely to afford an extended view was ascended, and the conclusion was

arrived at, that from this point there was no chance of proceeding to the southeast, and that we must, to attain our object, follow the river till an available point to leave it in the desired direction should be found. I detailed Lieutenant Parke to ascend the river, to endeavor to find a practicable pass at the source of one of its branches, while I should descend it for a similar purpose; and, as the services of Mr. Smith, on this survey, could be dispensed with, he was given a party, with the spring-wagon, to make a survey of the New Pass, examine the country lying between it and the Cajon Pass, and after a survey of this latter to return to camp. It was estimated that Lieutenant Parke and myself would be absent ten days, while Mr. Smith would require a few days longer to accomplish his surveys. Lieutenant Stoneman, with the escort, was to remain in camp.

I started with a very small party, on the 23d, down the river. At Depot camp it was a broad, shallow stream, abundantly wooded, and its bottom confined by terraces on either bank, from one to three miles apart. The water, however, soon sank in the sandy bed, reappearing generally at a point of rocks, or a contraction of the stream. The timber followed the direction of the water, and generally disappeared with it.

After descending about twenty-four miles, I made one of my camps at a rocky point where the water flowed freely, but only for a short distance. Here, the course of the river not being discernible, I was in doubt whether to follow the wagon-road, which I had no reason to suppose would leave water, or to go through an opening more to the south. There was but little choice between the two, and finally I determined to take the road. After travelling ten or twelve miles, I discovered that neither of the courses was the correct one, but that the river flowed through a cañon in the intermediate hills. Returning, I made camp at a place on the river conveniently situated, from which to make a reconnaissance of the southernmost opening.

As there was little chance of finding water after leaving the river, I took with me a pack-mule, carrying two ten-gallon kegs of water, by which means I was able to go thirty or forty miles and return. I started early, with two men, leaving the other two in camp, and proceeded in the direction of a high peak in a ridge ahead, which ridge seemed to terminate the opening. As we advanced, however, we found this to be a mere spur, extending into the opening, and not closing it. About sunset, I fortunately found a little dry grass, and being at the foot of the ridge, I made camp. As, by ascending the peak, I would be able to see a great distance in every direction, whereas my provisions would not allow of following the opening, I resolved to attempt its ascent, and, starting very early, succeeded in gaining its summit by daylight. Here I had an extended view. There were ranges of hills and mountains on all sides, which seemed to have no uniformity of direction. In a direction south, 25° east, the hills seemed to be more distant and lower. They looked white, like sand-hills, and were about twenty miles off. I could form a pretty good idea of this distance, as I could compare it with the distance from camp, both places being visible from where I stood. The direction of these low hills is about the same as that of the mouth of the Gila, which was distant 175 miles, and the nearest point of the Colorado river 125 miles.

I arrived at noon where I had left the men, and, having given our animals the last of the water, we turned our faces towards camp, where we arrived late at night.

About midway between the peak and camp was a singular isolated hill about 300 feet high. It was composed of very black volcanic rock, and its form that of a very symmetrical truncated cone, surrounded at its base by a circular horizontal bed of the same rock, the cone being in the centre. This bed was between two and three miles in diameter, its edges well marked, and

rising from two to six feet above the surrounding gravelly plain. I regretted very much that I could not stop to examine and ascend it; but, as it was, I was fearful our mules would give out before reaching camp. From its peculiarly symmetrical appearance, from the volcanic nature of the rocks, and from its singularly isolated position, every one must be struck with its similarity in appearance to a volcanic crater.

The next morning I moved up the river to a point I had selected, from which I intended to go out into the Basin towards the Tejon, to connect with the partial line before described. The only point in the Mohave bottom from which the Tejon mountains can be seen is about 25 miles below Depot camp. This is due to the terraces and low hills on the river's bank. From here I went to a low point of hills, about 10 miles towards the Tejon, and finding the nature of the Basin to be of the same character as heretofore described, and being perfectly satisfied of its practicability for a railroad route, I retraced my steps, and finally returned to Depot camp on the 1st of November.

Lieutenant Parke returned from his examination up the river on the same day. He reported that he explored the headwaters of the river, and found the mountains near its source to be exceedingly high and rugged. The precipitous ravines and side-slopes were of such a nature as to render travelling on muleback very difficult and often impossible. This reconnaissance demonstrated the impracticability of crossing the mountains east of the Coast range, and near the headwaters of the Mohave, and at the same time it furnished much useful topographical information.

The result of these preliminary examinations seemed to force the following conclusions, viz: 1st. That it was positively impracticable to reach the mouth of the Gila by ascending the Mohave, and crossing the mountains east of the Coast range. 2d. That for 60 miles at least below the Depot camp there were ranges of hills and mountains south and southeast of the river, which presented an impassable barrier to progress in a direct course towards that point. The evident deduction was that a circuit must be made either to the west or to the east to turn these mountains.

Under these circumstances it was determined to divide the party into two parts. Lieutenant Parke, with the wagon train, was to cross the Coast range at the Cajon Pass, and recross it at the Pass of San Gorgonio, thus turning the headwaters of the Mohave river and the high mountain of San Bernardino, in which it has its source. Being thus once more east of the Coast range, he was to follow along its eastern base till he came to Warner's Pass, where he was to select a camp and commence the survey of that pass. In the meantime the second party, with pack-mules only, would descend the Mohave river to its supposed junction with the Colorado, and thence down that river to the mouth of the Gila. This latter party would be accompanied by the whole of the escort, as we knew the Indians on the Colorado to be numerous.

While waiting for the return of Mr. Smith and his party, preparations were being made to follow out this plan, and numerous observations were taken to establish astronomically the position of this, one of our most important camps.

Mr. Smith returned on the 6th of November, after a successful expedition, the results of which will be detailed hereafter. Early on the morning of the 8th the wagon train started, and shortly after the packs were ready, and we were on the trail down the river. On the evening of the 10th we made our camp at the lowest point I had reached on the river during my preliminary examination. From here we followed the broad river-bed for 15 miles, having

clay bluffs on each side, when we entered the cañon, which is about seven miles long, and had running water throughout its whole length. The bed of the stream in the cañon is from 100 to 150 feet in width. On either side the clay bluffs rise often over 100 feet. They are vertical, and, by the action of the water, the surface has in many places assumed the form of Gothic pillars. The clay presents every variety of beautiful and delicate tints—purple, pink, blue, yellow, &c. In the cañon we found cane growing, similar to that mentioned as found in Walker's Pass, and large quantities of it had been cut by the Indians. We saw, however, no fresh Indian signs.

Upon emerging from the cañon, we entered a sandy plain, and at once lost all signs of the river-bed. After travelling 13 miles across this plain, we were fortunate enough to find a hole containing water, and here we made our camp late at night. The water was barely sufficient for our nearly exhausted animals, and a long time was occupied in giving them a scanty supply. This plain had an abundant growth of mezquite trees. We afterwards found some uninhabited Indian huts near here, and saw an abundance of old Indian tracks, but no Indians.

In the morning, upon taking a survey of our position, we found we were near the centre of an irregularly shaped plain, surrounded by hills. To the southeast appeared an opening, and here we concluded was the outlet through which the Mohave continued its course. We went in this direction about thirteen miles, the first seven or eight of which were over low sand-hills; but afterwards we travelled in the dry bed of a wash, which we found we were *ascending*. Being convinced that we had left the Mohave, and the men who had been sent in search of water having been able to find none, we returned to our camp of the morning. This was another very fatiguing day for the animals, and after reaching camp, there being so little water in the hole, which filled very slowly, it took till 2 a. m. to water them. We observed to-day that to the north of our camp was a large lake-bed, and here we inferred the waters of the Mohave were collected. The question now was, whether this lake had an outlet, or whether it was a basin, and the terminus of the Mohave. To ascertain this point, Lieutenant Stoneman and myself started to examine the lake, which was about fifteen miles long, and covered with an incrustation of salt, exceedingly bitter. We, however, returned to camp late, without any positive result. Not being willing to move the command upon an uncertainty, I resolved to devote one more day to examination. To the east of our camp was a high range of barren mountains, its crest from fifteen to twenty miles distant. Lieutenant Stoneman and myself ascended to the summit of one of the nearest peaks, from which we had an extended view. To the eastward were to be seen nothing but mountains; we saw, however, that to the northward of the salt lake, and not far distant from it, were several other lake-beds. Our view to the southward was bounded by mountains.

The result of these examinations was, that if the Mohave flowed beyond the salt lake, it could flow in no other than a northerly direction through these lake-beds, and the only thing to be done was to proceed in this direction, though directly contrary to the one we wished to go.

We had found at the base of the hills, on the edge of the salt lake, several fine springs, slightly brackish but not unpalatable. Around these was good grass. The camp was moved here, and the animals were refreshed by once more having as much to eat as they wanted.

On the morning of November 16, at 5 o'clock, we started by fine moonlight and travelled to the northern extremity of the salt lake, and thence on to the next one. We found the two connected by a ditch, cut by water in the clay soil, and about twenty feet wide, with banks two feet high. The two lakes were from three to four miles apart. The second one was six miles

long and three broad. The character of the second lake was entirely different from that of the first. It was a dry, hard clay-bed, on which the shoes of the mules scarcely made an impression; while the other was covered with salt, and in many places too soft to travel over. The bases of the hills on the west, and the mountains on the east, were immediate on the lake bank, and as we crossed it we could see there was no outlet in either of these directions; but to the northward the hills were low, and we expected to find here a passage where water could flow. On arriving at the north end of the lake, we found a very low ridge, connecting the hills on either side. We searched for a passage through this ridge, but could find none; but everywhere saw, in the gullies, that the water from rains flowed towards the lake. I hence concluded that the true sink of the Mohave river was in the salt lake, and that the second lake was formed principally from water flowing from the surrounding hills after heavy rains; but that in time of very high water in the salt lake, its surplus flowed through the ditch before mentioned into it.

We crossed this ridge, and at once descended into another valley some two hundred feet lower than the bed of the lake. After travelling four or five miles, we came suddenly upon a wagon-road. We knew it could be no other than the old Spanish trail, and this at once afforded proof that the Mohave river of the maps is a fiction. It was universally supposed by emigrants and others, that when the Spanish trail left the Mohave above the cañon, it never was on it again. The valley in which we struck the trail extended to the northward twenty or thirty miles, bounded on all sides by mountains.

We were now, according to our estimates, over 100 miles in a direct line from the Colorado, with a mountainous country between, and neither wood, water, nor grass that we knew of. To attempt to reach that river would have been madness. Our only alternative was to turn back. We took the wagon-road, and at midnight reached Agua de Tomaso, having travelled fifty-five miles without water.

Agua de Tomaso, (or, as I am told, more properly Agua de Tio Mes,) is simply a spring of bitter water, which does not flow more than a hundred yards, and is quite different from what maps generally represent it to be; for they often make it a stream 20 miles long. There was not enough grass here to subsist our animals, and we were, therefore, obliged to push on early in the morning to where the trail strikes the Mohave. From here we went by the usually travelled roads through the settlements to join Lieutenant Parke, whom we found near Warner's rancho, at Agua Caliente. We joined him on the 29th of November, and once more all the party was together.

MR. SMITH'S SURVEY.

I have deferred until now a report of the results of the survey intrusted to Mr. Smith, because I did not wish to interrupt the detail of facts connected with the Mohave river.

Mr. Smith left Depot camp on the 21st of October, with the spring-wagon and a small surveying party. Instead of following our circuitous trail, he attempted to go in a direct line to the entrance of New Pass, but found the ground cut up by gullies, and the yucca trees and brush very thick. He therefore regained the road, and, proceeding without further difficulty, arrived at and went through the New Pass. A full description af this pass has already been given.

On the south of the Santa Clara valley is a spur of the Coast range, running obliquely towards the sea, and known as the Susannah range. In order to pass from this valley to the valley of Los Angeles, this range must be crossed or turned. The latter course is easily pursued, as the range degenerates into low hills as the sea is approached; but this would greatly

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lengthen the road. The wagon road of the San Francisquito Pass crosses this range at a pass known as that of San Fernando, as it leads directly to the mission of that name. It was through this pass that Mr. Smith went, and I will now describe it:

SAN FERNANDO PASS.

Two small streams, rising near the crest of the Susannah range, and one-quarter of a mile apart, flow in opposite directions—the one north into the Santa Clara, the other south towards the mission of San Fernando. Between the two is a sharp crest, where the inclination is over 1,000 feet to the mile. This is the nature of this pass, which is only 8¾ miles from base to base. Leaving the Santa Clara, we ascend 2⅝ miles, at the rate of 43 feet per mile; then 1⅓ mile, at 260 feet per mile, which brings us to the base of the crest; having passed which by a tunnel, we descend 4½ miles, at 157 feet to the mile, to the southern foot of the pass. With a tunnel, this is decidedly practicable. The only question is, as to the expediency of increasing the length of the tunnel to reduce the grade of 260 feet. The Susannah range has been very little explored, and it is not improbable that other passes in it may be found presenting much less difficulties than this one.

Once arrived at San Fernando, the country may be traversed in almost every direction between that point, San Bernardino, and the coast.

About 21 miles southeast of San Fernando is the Pueblo de los Angeles, formerly the capital of California, when under Mexican rule. This place is celebrated for its delightful climate and fertile soil. Large quantities of grapes are exported to San Francisco, and considerable wine was formerly produced. The accompanying view (Plate X) was taken from a hill near the city.

From this place Mr. Smith passed over an interesting and fertile country to the valley of San Bernardino, and acquired much valuable topographical information. This portion of the route, surveyed by Mr. Smith, is perfectly practicable for railroads, and therefore I proceed at once to a description of the Cajon Pass, which he surveyed, and which leads from the San Bernardino valley, through the Coast range, towards the Mohave.

CAJON PASS.

The general direction of this pass is nearly north and south, the base towards the Pacific being more easterly than the summit. In approaching the summit from the Mohave there is no appearance of ascending a mountain. With the exception of a few low hills or undulations on the crest, it is apparently a continuous inclined plane. Arriving at the crest, we are at the summit of a very steep hill, descending which we come into the bed of the Cajon creek, 836 feet below the summit. The road then follows the creek down to the San Bernardino valley.

The survey commenced at the Pacific base, about 14 miles from the summit. For the first 6½ miles the average grade was less than 100 feet, and for the next 6½ less than 200 feet, averaging 165 feet to the mile. The ascent of the steep hill is now commenced. We ascend for 0.96 mile, at the rate of 534 feet per mile, then 0.23 mile at 1,271 feet, and arrive at a point 40 feet below the crest. In the descent from the crest we have 2¼ miles, at 207 feet per mile; after which is a nearly uniform slope of 90 feet to the mile to the Mohave river, distant from the summit 19 miles.

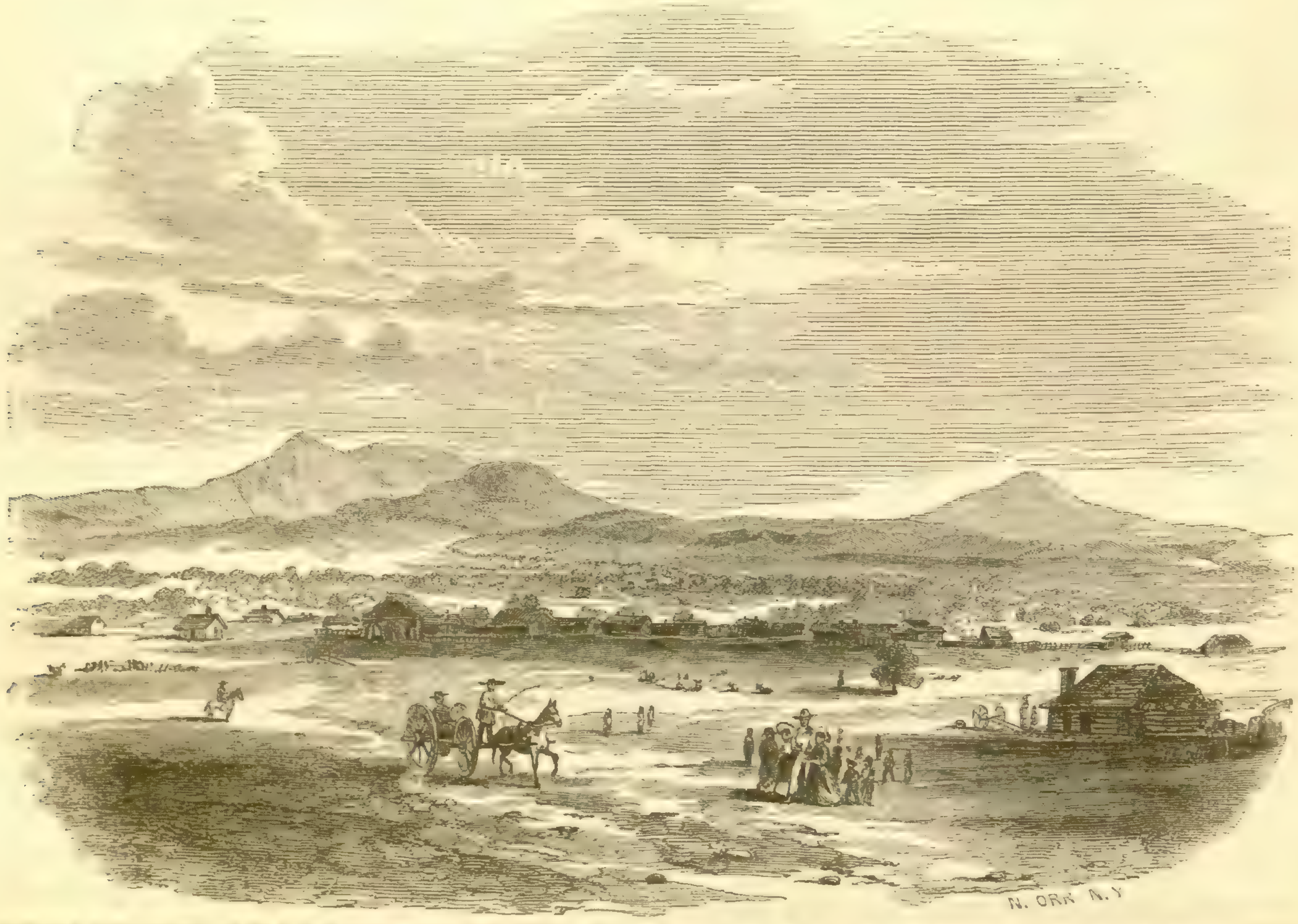
It is evident that the mountain here can only be passed by a tunnel. Taking the grades as given above with the corresponding horizontal distances—which were deduced from odometer measurement—to be correct, it is found by calculation that if we start a tunnel from the creek

at the base of the steep hill, with an ascending grade of 100 feet to the mile, the length of such a tunnel would be 3.4 miles. Such a tunnel would emerge on the eastern slope at a point below all steep grades, and from its eastern extremity to the Mohave no grade exceeding 90 feet would be required. In the Cajon creek the grades would be steeper, but probably could be much reduced by taking advantage of the side-slopes.

The survey of the Cajon Pass finished the work assigned to Mr. Smith, and the information he obtained was very valuable. His note-books show that his work was done in a very thorough manner.

LIEUTENANT PARKE'S ROUTE—SAN GORGONIO PASS.

On the 8th November, as before stated, the party was divided. The results of the expedition down the Mohave have already been detailed. Lieutenant Parke, with the wagon-train, passed through the Cajon without difficulty, and reached the Mormon settlement of San Bernardino, a flourishing little village near the mountain of the same name.



MORMON SETTLEMENT IN THE SAN BERNARDINO VALLEY, WITH A VIEW OF THE PEAKS OF SAN BERNARDINO AND SAN GORGONIO.

Having procured supplies here, he proceeded through the pass of San Gorgonio, thus once more arriving to the eastward of the Coast range. The pass was surveyed, and proved to be a very good one.

The high mountain of San Bernardino is the highest in the Coast range. Its height is not known with accuracy, but approaches 9,000 feet. Southeast of this mountain is the peak of San Gorgonio, nearly as high. These two mountains, whose peaks are 30 miles apart, approach each other at their base, and the open pass between is known as the pass of San Gorgonio, and

is one of the lowest in the Coast range, being but 2,800 feet above the sea. This pass, if named after one of the mountains, would more naturally take the name of the more prominent one; but it doubtless received its present name from that of the rancho, the land in the pass being styled in the Spanish grant the "Rancho de San Gorgonio."

SAN GORGONIO MOUNTAIN.

The above sketch represents Weaver's house, near the summit of the pass; the foot-hills of San Bernardino mountain are seen on the right.

The survey of this pass was commenced on the Santa Anna river, about two miles from the Mormon settlement. From here the line of survey followed up a dry branch of that river, and, passing the divide, descended another stream, dry except near its source, to the desert. The grades in this pass are so uniform that it is difficult, in its description, to say anything more than to state the degree of declination to be overcome. After ascending for $6\frac{1}{4}$ miles, at a grade of 45 feet to the mile, we have $18\frac{1}{4}$ miles to the divide, at an average grade of 78 feet; during the whole of which distance, with the exception of $1\frac{1}{3}$ mile at 127 feet, the greatest deviation from the average is eight feet per mile. Descending from the divide, we have 28 miles at an average grade of 69 feet. This pass is so uniform and open that it may be considered the best pass in the Coast range.

Having gained the eastern base of the mountains, Lieutenant Parke conducted his train along their base till he struck the wagon-road leading to Fort Yuma. Along the first part of the route the country was inhabited by friendly Indians. It was evident that here the land was below the level of the sea, and that they were travelling in the bed of what was once either a lake, or the head of the Gulf of California. Water was obtained near the surface by digging; a distinct water-line was visible on the rocks, and the barometer indicated a depression below

the sea-level of nearly 100 feet. It is highly probable that further from the base of the mountains the depression would have been greater. As they approached the wagon-road the ground was very much cut up by gullies, which, doubtless, would have been avoided by keeping further from the foot-hills. It was necessary to keep close to them, however, as the only chance of procuring water.

A mountain range extends from San Bernardino mountain in a southeasterly direction, nearly if not quite to the Colorado. Between these mountains and the mountains on the Mohave nothing is known of the country. I had never heard of a white man who had penetrated it. I am inclined to the belief that it is a barren, mountainous desert, composed of a system of basins and mountain ranges. It would be an exceedingly difficult country to explore, on account of the absence of water, and there is no rainy season of any consequence. I was informed by the commanding officer at Fort Yuma that there they usually had but one rain during the year, which fell in August.

The country included between the mountain above mentioned, the Coast range, and the Colorado, is level, or but slightly undulating, and is known as the Colorado Desert. In many parts it is destitute of vegetation.

Lieutenant Parke having struck the wagon-road, crossed the Coast range at Warner's Pass, and encamped near Warner's rancho, at Agua Caliente, where we joined him on the 29th of November.

It now only remained to examine the passes in the Coast range leading into San Diego, and the desert between the mountains and Fort Yuma, to complete the work which had been assigned to me. As far as I could ascertain, the only passes known to the citizens of San Diego, and advoe cated by them as suitable for railroad routes, were Warner's Pass and Jacum Pass. The latter was supposed to lie partly in Mexican territory. It was known that, even if the mountains were once crossed at Warner's Pass, it would be impossible to follow the wagon-road to San Diego, and that another route must be found. In Warner's Pass a creek rises and flows towards the Pacific, but where it empties was not known. I instructed Lieutenant Parke to descend this creek to its mouth, and then proceed along the coast to San Diego, where he would gain as much information as possible with regard to the passes in the mountains; and should the Jacum Pass be favorably spoken of, to proceed to its examination, and then return to San Diego. In the mean time I intended to cross the desert to Fort Yuma, and expected to return and arrive at San Diego about the same time. The services of the escort being no longer required, Lieutenant Stoneman, with the wagon-train, proceeded at once to San Diego.

WARNER'S PASS.

In order to have the means of measuring distances with the odometer, and also to carry barley for the mules, I took a wagon with me to Fort Yuma. We started on the 1st of December; Lieutenants Parke and Stoneman both starting at the same time on their respective routes. Our route lay through Warner's Pass to the desert, and thence across to the Colorado. Warner's Pass had already been surveyed by Lieutenant Parke, and I will now describe its prominent characteristics.

Leaving Warner's house, we reach the actual summit of the Coast Range in five miles, and in ten miles more we arrive at a little valley called San Felipe. The drainage of the valley is through a narrow, rocky cañon, the mountains on each side rising precipitously, and being covered with huge blocks of granite. This being impracticable for a wagon-road, the trail is

led over a collateral divide, 400 feet above San Felipe, and is brought upon the headwaters of another creek; it then follows this creek to the desert, continually descending, with the exception of half a mile, where it crosses a hill to avoid a cañon of the creek.

From Warner's to within $2\frac{1}{4}$ miles of the summit the grades are easy; but from here we have $1\frac{1}{4}$ mile at 215 feet per mile, and 1 mile at 280 feet per mile. Descending from the divide we have a grade of 333 feet for $1\frac{1}{3}$ mile, and of 140 feet for 4 miles more. Suppose we connect the point where the ascending grade of 280 feet commences, with that where the descending grade of 333 feet ends; we should have a tunnel $2\frac{1}{2}$ miles long, with a grade, descending towards San Felipe, of 100 feet to the mile; and to reach such a tunnel we have to overcome a grade of 215 feet per mile.

Having arrived at San Felipe, a road might be made through the cañon above mentioned, with immense labor and expense. It would have to be built on the side-hill, and there would probably be required from 10 to 15 miles of road of the most expensive character to reach the valley at the lower end of the cañon; for although this cañon is but little more than four miles long, the fall averages at least 400 feet to the mile.

PASS BETWEEN SAN FELIPE AND VALLECITO.

But if the cañon be rejected, and the route at present pursued by the wagon-road be preferred, we must ascend from the valley of San Felipe, and cross the collateral divide between that valley and the headwaters of Carrizo creek. To do this we have a gentle ascent till near the divide, when a tunnel of 300 yards would be required to pass the steep pitch, where the ascent is at the rate of 940 feet and the descent 740 feet per mile. Having passed the divide, the wagon-road lies in the bed of the stream, dry during the greater part of the year. The descent

for 2⅓ miles averages 180 feet per mile, and for nearly all this distance the bed is very narrow and tortuous, and the rocky hills on either side exceedingly precipitous. In one place the rocks have been cut away to afford room for the passage of a wagon. This bed of the creek would not answer for the railroad, as in the wet season it is full of water.

The only other impediment before reaching the desert is at a point where the creek cañons. The wagon-road avoids this by passing over a steep hill. For a railroad, heavy side-cuttings, and probably a tunnel of a quarter of a mile, would be necessary. Carrizo creek is dry, except at occasional points where the water is forced to the surface by rock. There is a constant supply of water where it emerges from the hills to lose itself in the desert. The name is Spanish, and means a kind of reed. It is applied, in California, particularly to that reed from which the Indians collect sugar.

THE COLORADO DESERT.

The distance from Carrizo creek to the Algodones, the first point where the road strikes the Colorado river, is 80½ miles. The whole of this distance is nearly horizontal, offering, topographically, not the slightest impediment to the construction of a railroad. The main difficulty is the barren nature of the country and want of water. It is believed that the latter may be obtained in any desired quantity by digging. Not an inconsiderable portion of this desert is below the level of the Colorado river. In 1849 this river broke through its banks, and the water flowed inland for some two hundred miles, forming what is known as New river. In many places it formed lagoons, while in others it confined itself to a narrow channel. The water in the connecting channels having dried up, the lagoons still remain, and are of great benefit to the emigrant.

Near the Colorado, and north of the road, is a strip of country about twenty miles long, covered with sand-hills, and these have often been spoken of as a serious obstacle to the railroad. From observations made by Mr. Blake, it is shown that these hills may be passed, either to the north or south, without difficulty. The discussion of the character of these sand hills, and of the desert generally, appertains more to geology than topography. This subject has been treated so ably and fully by Mr. Blake, that it would be superfluous for me to enlarge upon it. It is sufficient for me to say that the desert may be considered the least difficult part of a railway route in California.

At the mouth of the Gila the banks of the Colorado are high, and the river narrower than its average width. Generally there is a wide bottom subject to overflow, but this is not the case at this point, and hence it presents advantages for bridging not frequently found.

During my return-journey to San Diego I broke the only barometer I had with me, which prevented my making a profile from Warner's to that place, as I had intended. This is the less to be regretted, as the route by the wagon-road on which I travelled is so utterly impracticable, that it would have been wasting time to have attempted more than a survey with the eye. I am aware that many of the ascents and descents may be avoided; but there are others, which offer serious difficulties, which must be encountered. The country between the crest of the Coast range and the coast near San Diego is filled with ranges and spurs, and a minute reconnaissance would have to be made before it can be mapped with any degree of accuracy. The broken and rugged character of the region may be inferred from the annexed sketch taken from a hill overlooking the battle-field of San Pasqual. The broad slope bordering the mountains and extending to the Pacific is visible in the distance.

COLORADO DESERT AND SIGNAL MOUNTAIN

MISSION OF SAN DIEGO

I arrived at the Mission of San Diego on the 19th of December. This mission is located in a long, narrow valley, formed by the streams descending the slope, and is now occupied as a military post. There is a fine grove of olive-trees in front of the mission buildings.—(See Plate XII.)

On the 20th of December Lieutenant Parke came in. He reported that he had followed to the sea the creek which rises in Warner's Pass, and found it emptied near the Mission of San Luis Rey. The creek in many places passed through rocky cañons impassable for mules, and Lieutenant Parke is of the opinion that it is unfit for railroad purposes. Leaving San Luis Rey, he travelled near the coast to San Diego, and here he could gain no information of any other pass than the Jacum Pass. He therefore made a rapid reconnaissance of this pass, and became convinced it was utterly impracticable. The mountains were high and rugged, and it was almost impossible to travel on muleback off the trail.

From all that I saw and could learn, I am forced to the belief that there is no pass leading directly into San Diego. To demonstrate this without a doubt, a detailed examination must be made, and if properly done should occupy three or four months of field duty. But a very small party would be required for this work, and the result would be a good topographical map of the country.

The field-work of the expedition being now concluded, the party was discharged, with the exception of the scientific corps, who, with myself, proceeded to San Francisco to compile the notes of the survey, and prepare a report.

GENERAL DEDUCTIONS.

In the foregoing description of the portions of country surveyed, I have endeavored to show the nature of the passes, &c., by numerical data, so that any one may be able to judge as well as myself of their adaptability for railroad purposes. I will now endeavor to state what, in my opinion, are some of the necessary results of the conformation of the country as it has been shown to exist.

Under the supposition that a road has been constructed from the Mississippi river to the mouth of the Gila, if the question is simply how to continue that road to the Pacific, the answer is at once apparent. It would follow a nearly direct line to the entrance of the San Gorgonio Pass, the best in the Coast range; then through that pass to the San Bernardino valley; and from there to San Pedro, or some other point in its vicinity on the coast. But the port of San Pedro has no harbor; and, in fact, the only really good harbors on the coast of California are those of San Francisco and San Diego. It hence becomes advisable to examine into the best routes to these two places.

To go from the mouth of the Gila to San Francisco, we must still go through the pass of San Gorgonio, unless we follow up the Colorado river, till we can find a place to leave it, and cross the Basin to the mountains. This latter route is mostly unexplored; but it is believed the difficulties of crossing the Basin will cause the preference to be given to the former. Having arrived in the San Bernardino valley, the road must either follow near the coast, or it must recross the Coast range, cross the Sierra Nevada, and enter the Tulare valley. Whether there be a practicable route in the Coast range or not, is a problem as yet unsolved. A party is now in the field surveying that portion of the country. To follow the other route we must cross from the valley of Los Angeles to that of Santa Clara, and thence by the New Pass to the

Great Basin, when we can, without difficulty, reach the base of the Sierra at any desired point. Of all the passes surveyed in the Sierra, the Tah-ee-chay-pah Pass has been found to be the best. Going then from New Pass, in nearly a direct line across the Basin, to the entrance of Tah-ee-chay-pah Pass, we cross the Sierra, and enter the Tulare valley. From the head of this valley to the navigable waters of San Francisco bay, we can descend at once without a single obstruction, for it is not at all necessary to follow the route taken by our wagon-train, crossing Livermore's Pass; but it is preferable to follow the shorter route, going at once to near the mouth of the San Joaquin river, and thence along the shores of Suisun bay to Martinez, thus avoiding all mountains. But this road does not lead directly to San Francisco. In order to reach that city it will be necessary to cross the Coast range again. This range has never been instrumentally explored, except at one or two points; but there is very little doubt but that it may be crossed at Pacheco's Pass, or in its vicinity; in which case the road would enter the valley of San Juan, from which, passing through the San José valley, and along the shores of San Francisco bay, it may be brought into the city itself. The distance from the mouth of the Gila to Martinez by the route indicated would be 680 miles, and to San Francisco by Pacheco's Pass about the same distance.

To reach San Diego from the mouth of the Gila the road would have to go through the pass of San Gorgonio, and along the coast turning the mountainous country which lies to the south; for Warner's Pass presents so many difficulties that, in my opinion, it can never be used for a railroad route. The distance to San Diego by the San Gorgonio route would be 315 miles.

Should the road, instead of being built to the mouth of the Gila, strike the Colorado higher up, and, crossing the Basin, ascend the Mohave river, to reach San Francisco it would leave that river 25 miles below the point where the Spanish trail strikes it, and from thence follow a direct line to the entrance of Tah-ee-chay-pah Pass.

CONCLUDING REMARKS.

Accompanying this report are tables giving the data from which the profile of each pass was made, and the result of the calculations; also a profile of each pass, and four maps. As a minute survey of the Tejon Pass and the Cañada de las Uvas was made, I have made a separate map of each of these passes, on a large scale, accompanied by a double profile—the one obtained from barometric measurements with the level. I have made also a separate map, to include all the passes in the Sierra Nevada, from Walker's Pass, on the north, to the Coast range. This portion of the country was thoroughly examined. The general map, including the whole route, from Benicia to Fort Yuma and San Diego, is on two sheets. I have refrained from putting anything on this map that was not positively known, and it is chiefly the result of my own examinations. I am indebted, however, to the notes of Captain W. H. Warner, for information concerning some portions of the Coast range. Captain Warner had been engaged for two years in surveying in the lower part of California; and, had he lived, doubtless would have produced an excellent map of that portion of the country. As it is, his notes have never been compiled. I consider these maps, profiles, and tables to constitute my report. In these everything is presented in a concise form, and what I have written is merely a translation into words of what is here expressed in numbers and drawings.

The instruments for astronomical observations which I had, were a sextant, made by Gambey, of Paris, and two large chronometers, one by Charles Frodsham, No. 1961, the other by Dent, No. 2057. Observations were taken as frequently as circumstances would admit, numbering

60 observations for time, and 83 for latitude. At the Depot camps we had opportunities of multiplying observations, so as to test thoroughly our chronometers, and the results were very satisfactory, as far as the Mohave river. The chronometers were enclosed in leather cases, and these were placed in a valise made for the purpose, and were transported in the spring-wagon, except where the road was rough, in which case they were carried by hand. Upon leaving the Mohave Depot camp, to follow down the river, I was obliged to pack them on a mule, and though the mule was led, and every precaution taken, we found that they changed their rates, and the longitudes obtained by calculation were not reliable.

A party properly equipped for the field should be provided with *at least* three chronometers. Having but two, if one suddenly changes its rate there are no means of ascertaining which one it is without a series of observations, which would cause delay and might much embarrass the operations of the party. It is my opinion that little reliance can be placed upon chronometers which are transported on pack-mules.

The barometers which were used in the survey were constructed by James Green, of New York. Two of these were syphon barometers and two cistern, of the pattern used by the United States Medical Department. An aneroid barometer was also carried.

As the observations for the profiles of the Tejon Pass and the Cañada de las Uvas were made by both barometer and spirit-level, I have been enabled to compare the results by each, and have presented them in the profiles of these passes attached to the maps. These profiles show that, by the ordinary methods of computation, the results from the barometer and level agree very closely, the difference not being sufficiently great to affect the questions of grade and practicability. But it is believed that, from the data obtained during the survey, an improved method of computation may be deduced, and the deviation of the barometric from the true altitude very much reduced. If this should prove to be the case, it will add greatly to the usefulness of the barometer as a surveying instrument.

PART II.

VICINITY OF FORT MILLER

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

ROUTES IN CALIFORNIA, TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, EXPLORED BY LIEUT. R. S. WILLIAMSON, CORPS TOPOGRAPHICAL ENGINEERS, IN 1853.

GEOLOGICAL REPORT,

BY

WILLIAM P. BLAKE,

GEOLOGIST AND MINERALOGIST OF THE EXPEDITION.

WASHINGTON, D. C.

1857.

WASHINGTON, D. C., *April* 6, 1857.

SIR: I have the honor to submit, herewith, a Report upon the Geology of the route for a railroad to the Pacific, examined by the Expedition under your command in 1853.

Very respectfully, your obedient servant,

WM. P. BLAKE,

Geologist and Mineralogist of the Expedition.

Lieutenant R. S. WILLIAMSON,

Corps Topographical Engineers.

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I.

ITINERARY,

OR

NOTES AND GENERAL OBSERVATIONS UPON THE GEOLOGY, MINERALOGY, AND AGRICULTURAL CAPABILITIES OF THE ROUTE.

CHAPTER I.

ISTHMUS OF DARIEN TO SAN FRANCISCO—SAN FRANCISCO TO THE SAN JOAQUIN RIVER.

Aspinwall on alluvial ground.—Fossils.—Tertiary fossils at Gatun.—Argillaceous sandstone at Barbacoas.—Chagres river.—Drift near Gorgona.—Boulders and river-drift of igneous rocks at Gorgona and Cruces.—Cruces to Panama.—Summit-ridges of the mountains, probably of compact greenstone.—Panama.—Strata of red sandstone.—Lignite.—Panama to San Francisco.—Basaltic islands.—Gulf of California.—Mountains of the peninsula.—San Diego.—Hills of modern strata.—Islands of Santa Barbara channel.—Arched rock, Anacapa.—Point Conception.—Change of temperature at Cape Conception.—Bitumen.—Point Pinos, Monterey.—Granite.—Golden Gate, San Francisco.—Sand-beach.—Sandstone and sand hills.—San Francisco to Benicia.—Sandstone strata.—Rounded hills.—Stratum of conglomerate.—Martinez.—Mount Diablo and Diablo valley.—Sandstone and conglomerate.—Diallage rock from Mount Diablo.—Cracks in the soil.—Livermore's valley.—Livermore's pass.—Strata of sandstone and conglomerate.—Outliers of conglomerate.—Effect of the fires on the wild oat.—Elkhorn.—Plain of the San Joaquin.—Sloughs and marshes of the river.

June 6, 1853.—Left New York for Aspinwall in the steamer Georgia, and arrived on the morning of the 15th. The highlands of Porto Bello were seen on the left as we entered the bay, and on the right several high peaks loomed up in the distance, their deep blue color contrasting finely with the luxuriant tropical verdure of the shores. Aspinwall is built on marshy, alluvial ground; the margin of a tropical swamp. Wharves have, however, been built beyond the water line, and the intervening space was being filled in with earth brought down on the railroad from a place called Monkey Hill, generally known on the Isthmus as the burial ground for thousands who have died of the malarious fever contracted during the construction of the road. The earth is clayey, without much sand, and is strongly colored by oxide of iron and black films—apparently, oxide of manganese. It is filled with casts of fossil shells; all marine. Bivalves were most numerous, and among them *Pectens* and *Tellina* were recognized. Other casts were probably of the genus *Turritella;* a tertiary or post-tertiary age is thus indicated for the formation from which the clay is obtained.

Aspinwall to Barbacoas, June 16.—We proceeded from Aspinwall to Barbacoas by the railroad; the latter place is on Chagres river, and the present terminus of the road, the bridge not being complete. At Gatun, or Monkey Hill?, where we stopped for a few moments, I obtained several fossil shells from the embankment at the side of the road. They are very numerous, and well preserved in a greenish sandy clay, which is very soft, and apparently of quite recent formation. For want of time, only three species were procured. These have since been examined and described by Mr. T. A. Conrad, and are new species of the genera *Gratelupia, Meretrix,* and *Tellina.*—(See Appendix, Article II.)

At Barbacoas, the bank of the river is high and formed of stratified rocks. They form a bluff about one hundred feet in elevation, and the bedding is distinct. The strata, apparently, dip to the west at an angle of five degrees, and the trend is north and south. The strata are argillaceous sandstone, and have a grayish green color.

Barbacoas to Cruces.—We took boats at the foot of this sandstone bluff and proceeded up the river. The banks for nearly the entire distance were completely hid by the dense and beautiful tropical foliage, so that the rocks were not visible. The river terrace, or bank, appeared to vary from ten to twenty feet in height. Some large boulders, or drift-rocks, were seen on a high hill, where a cutting for the railroad was made. At Gorgona, the beach pebbles were principally trappean and basaltic, with some agates. A bank of conglomerate, with some large boulders, was also seen. At Cruces, similar pebbles and boulders, or a coarse river-drift, was found, some of the rounded masses being over a foot in diameter. This place is near the base of the high mountains.

Cruces to Panama, June 17.—Disembarking at Cruces, at 10 P. M., we remained over-night, and in the morning mounted mules for Panama. Soon after leaving the town, the path led through a narrow defile in a soft rock, which appeared to be similar to that seen at Barbacoas; but it was so much overgrown with green moss, and covered with mud, that its character could not be determined. The path, however, was only wide enough for a mule to squeeze through; and it appeared to have been worn down by the feet of animals alone, as there were deep foot-holes at regular distances. From this place to Panama very few observations on the rocks could be made. They were obscured by vegetation beyond the path; and along it the only formation visible was a deep, semi-fluid, red and black mud. The highest part of the route, however, (the summit of the mountains of the Isthmus,) appeared to be formed of compact greenstone. The paving-stones, also, which were used to construct the old road in the time of the buccaneers, appear to be of basalt and greenstone. Indeed, at one point, near the western base of the mountains, I observed a rock decomposing and breaking up into globular masses, like some of the trappean and trachytic rocks. The city of Panama is built directly upon the shore of the bay, and it is underlaid by nearly horizontal strata of a red sandstone, which much resembles some portions of that in the Connecticut river valley. It is regularly stratified, as can be seen at many points about the shore, at low tide; and the edges of the beds rise in succession over a wide surface, which is left uncovered by the water. The strata dip southward at an angle of about five degrees, and they are composed of alternate layers of compact red sandstone and light colored shales. The layers of the sandstone will average fifteen inches in thickness, and the shales six to ten. The gentle dip of the strata permits broad surfaces of each layer to be exposed to view; and when the tide is out the formation can be conveniently examined. Several specimens of the rock, containing remains of vegetation converted to lignite, were obtained. The surface of the rock was also marked in many places by curious figures, in relief, resembling roots of plants; and one, nearly two feet in diameter, had the form of specimens of *Comatula.* No fossil shells could be found; but this sandstone is probably Tertiary. It is used in the construction of walls in the city, and the old fort is built of it. The stones of the walls are much worn away by the weather, and present the curious appearance of being hollowed out towards the centre, the mortar of the joints not weathering so rapidly as the rock.

Panama to San Francisco.—We left Panama on the 20th of June, in the steamer California, Captain Whiting. The high hills and mountains, covered by dense tropical vegetation to their summits, with the towers and ruins of the city at their base, presented a beautiful appearance as

we left the anchorage. We passed several small but high islands in the bay, all of them with steep, rocky shores, much obscured by vegetation. One of these islands was distinctly basaltic; the rock presenting a columnar structure. We subsequently passed one which appeared to consist of horizontal strata, capped with a thick layer of basalt, with columnar sides. The bold relief and bluff character of this western coast of the Isthmus contrasts strongly with the broad and low region on the east, and we have, in fact, a miniature representation of the conditions which obtain on the broadest part of the continent.

June 30.—Crossed the Gulf of California, and came in sight of the Cordilleras of the Peninsula of Lower California. The end of the Peninsula is very broad, and presents a bold front to the south. Cape St. Lucas is formed of a succession of precipitous, rocky islands, appearing as if they had been split apart, and from the main land. The mountains form an unbroken and lofty chain throughout the whole length of the Peninsula.

San Diego, July 4.—We entered the harbor of San Diego on the south side of some comparatively low and rounded hills, free from trees. They are of stratified sand and gravel, and have a modern appearance. The sea has worn away a large part of the outer point, and exposed the loose, earthy character of the strata to view.

In passing up the coast through Santa Barbara channel a fine view of the islands was obtained. They are rocky and barren, and apparently formed of stratified rocks. An interesting example of the wearing power of the sea was presented at the eastern end of the island of Anacapa, a perfect archway having been formed in a thin wall-like mass of rock.

Point Conception.—Point Conception is a prominent feature of the California coast, and holds nearly the same relation to it that Cape Hatteras does to the Atlantic. It is formed of low hills, with smooth, rounded outlines, projecting out into the sea several miles beyond the high ranges which form the coast further east. The rocks, seen from a distance, appear light-colored and stratified, but, at the water's edge, are dark, and appear to resist the furiously-breaking surf very well. On nearing the point and passing it, the stratification was distinctly visible, with a dip varying from five to fifteen degrees by the clinometer. The end of the point is a vertical cliff, probably less than 100 feet high. The smooth, rounded surface of the point supports a growth of wild oats and weeds, and a herd of cattle were feeding on them.

On rounding this cape the temperature suddenly changed, and overcoats and gloves were necessary for protection against a cold northwest wind.

Numerous broad and black sheets of bitumen were seen floating on the waves, and I was informed that it floated down a stream from a short distance in-shore, where there are springs of this material.

Point Pinos, Monterey, July 6.—We came in sight of Point Pinos, the headland of the bay of Monterey. It is formed of hard rocks, which project into the sea towards the northwest and thus form a cove, sheltered from the southwest winds. We here, for the first time on the California coast, found the surface covered by trees. The point is thickly wooded with pines. A strange and striking contrast is presented by the whole coast up to this point with the green and wooded shore of the Atlantic seaboard. At this season the California shore presents one uniform shade of yellow or brown; the grasses and wild oats being parched and withered by the drought. The absence of trees and forests is peculiarly favorable to geological investigation, permitting the outline and surface of every hill and mountain to be seen.

The rocks of the point are of white or light-grey granite, and are considerably rounded and worn by atmospheric action and the wash of the sea. The city is built on a beautiful slope, and

the ground looks rich and fertile. It is extensively cultivated, and fields were seen enclosed by the well known Virginia or "crook fence." A steam saw-mill was in operation making boards from the pine logs. We remained at the anchorage only thirty minutes, long enough to land the mail in a small boat.

Golden Gate, July 7.—Reached the headlands of the harbor of San Francisco early this morning. The fog was so dense that the shore was invisible until we were close upon it. A long and wide beach of white sand, which appeared to extend far inland, was passed before we entered the channel leading to the bay. Numerous small rocky islets fringe the headlands and make a dangerous surf. These islands were partly covered with sea-birds and the huge seals called sea-lions, *Phoca* (*Otaria*) *jubata.* The rocks are probably sandstone, but the fog was so dense about the top of the hills that the sky outline could not be observed. The shores are precipitous; vertical cliffs of rocks being exposed and apparently the result of the undermining action of the waves.

San Francisco is built on the inner or eastern shore of the peninsula and at the foot of several hills of a brownish sandstone, partly covered with a thick soil, and in other places by sand. Towards the Mission the sand-hills are an important feature of the place, being high and steep, and covered in most places by a low growth of vegetation, principally shrubs and evergreen and dwarf oaks. Many of the buildings are constructed of a hewn sandstone, of a light-drab color, brought from Benicia, and of a beautiful light-colored granite brought from China. The fragments of the sandstone from Telegraph hill, near North Point, are so much stained and rusted by partial decomposition, and break up into such angular pieces, that they resemble trappean rock which has been exposed to the weather.

SAN FRANCISCO TO THE SAN JOAQUIN RIVER.

Benicia, July 8.—In passing up the bay of San Francisco by steamer to Benicia, many outcrops of stratified rocks are visible along the shores. Several small islands are also seen, one of them very red, being composed of a ferruginous rock, probably sandstone; and another quite white, it being covered with birds, which leave a layer of guano as white as lime. In the face of a bluff, not far from Benicia, the edges of stratified rocks were seen, the dip being about forty-seven degrees, and towards the southwest.

At Benicia the hills are high and beautifully rounded, the surface being smooth and devoid of trees or shrubs. At this season, the wild oat, which covers the surface, is golden yellow; but here and there the long dry straw has been set on fire, and broad acres are burned off, leaving a black, charred waste. The general character of the surface of these hills is well shown by View II.

Near the old barracks, there is an outcrop of coarse-grained sandstone and conglomerate. This being harder than the strata of finer materials, has resisted degradation, and now forms the apex of the hills at many places. Its trend at one point appeared to be north 70° west. Where first observed, the conglomerate was composed of small, thoroughly-rounded pebbles, of nearly uniform size, and not larger than peas or beans. Much larger pebbles were found at other points, and were probably derived from an adjoining stratum. The great bed of conglomerate extends down to the water, and forms the headland, called Navy Point. At this place there is a fine exposure of sandstone, strata, and shales, all conformable with the conglomerate. A good section was obtained. The strata are partly decomposed and rusted by

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exposure, and some seams of gypsum were found. At a quarry a short distance from the point, several blocks of soft sandstone were found to contain impressions of the stems of plants, some of them in the form of lignite; but they are not sufficiently well preserved to be identified.

VIEW FROM BENICIA, LOOKING SOUTHWEST.

Martinez, July 10.—Left Benicia and crossed the straits of Carquines to Martinez, a small town directly opposite. The hill-slopes on this side of the straits are tolerably well wooded with an evergreen oak, thus contrasting strongly with the barren slopes of the Benicia side. The trees are, however, principally confined to the valleys or depressions of the hill-sides, and do not obscure the outlines of the hills, which are beautifully curvilinear. The town is built on a nearly level plain, between two ranges of hills, and our first camp was upon this plain, on the banks of a small brook. In the channel of this stream, an outcrop of sandstone, similar to that at Benicia, was observed. Its trend was northwest and southeast, approximately.

The geological formations of Benicia and Martinez appear to be similar; Martinez is underlaid by sandstone strata resembling those of Navy Point, and they may be regarded as the continuation of the same series. The trend or direction of the strata is the same on both sides of the straits, and it indicates that the current has cut its channel by denudation alone, without the aid of any great dislocation or disturbance of the strata. This similarity of composition and direction of the strata on the opposite sides of the straits was also observed by Mr. P. T. Tyson, and noticed in his report.[1]

This was our first camp in the open air, without tents. The remarkable brilliancy of the stars throughout the night, and the absence of clouds or dew, could not but be observed, especially by those unaccustomed to the climate. The heavens were as brilliant as in the clear frosty nights of mid-winter in New England. The strange and peculiar yelping and howling of the *coyote*, or California wolf, was heard for the first time. They came very near the camp on all sides, and one animal seemed indefinitely multiplied, so various and involved were the sounds.

Martinez to Livermore's Pass, 44 *miles, July* 11–16.—The mules were brought into use for the first time, and the line of survey was commenced. We passed southward by a good road winding among the smooth round hills. Fine farms were seen, well-fenced, and giving evidence, in the abundance and richness of the crops, of the great depth and fertility of the soil. The high peak of Mount Diablo was constantly visible beyond the hills on our left, and several miles distant. It also formed a prominent feature in the landscape at Benicia, and is visible

[1] Senate Ex. Doc. No. 47, 31st Cong., 1st sess., 1850, p. 16.

from San Francisco and the ocean, near the Golden Gate. This mountain is considered volcanic by many in California, but no evidence of it has yet been seen.

Our second camp was in a grove of oaks on the bank of a small brook. Here a slight dew fell during the night. Temperature of the air at sun-down, 74°; at 9 p. m. 64°.

The narrow valley in which we had been travelling gradually expanded, and at one place reached nearly to the foot of Mount Diablo, forming a plain of considerable extent. This was timbered near the hills and the mountain by a growth of evergreen oaks mingled with the common "white oak" of California, (*Quercus Hindsii.*)

The general appearance of this valley or plain, with Mount Diablo beyond, is shown in the outline engraving. The foot hills are almost devoid of trees, and present singularly rounded outlines. They are covered with the dead stalks of the wild-oat.

An outcrop of coarse-grained sandstone was seen near the border of the valley. The rock contained large pebbles, most of them as large as hens' eggs, and similar to those collected at Benicia.

MOUNT DIABLO AND DIABLO VALLEY.

About three miles beyond the camp, July 12th, another outcrop of a conglomerate was found, trending about north 30° west. From this place high hills of stratified rocks were visible at the foot of Mount Diablo. Two miles beyond, and near the banks of a small stream, which we followed, a succession of sandstone strata were exposed in a bluff about six hundred feet long. They were highly inclined at an angle of 60°, dipping easterly, the trend being nearly northwest and southeast. The strata are soft and not firmly consolidated, consisting of argillaceous sandstones of different degrees of fineness; some of the beds being coarse-grained and filled with pebbles. The cast of one valve of a shell of the genus *Cardium* was found on the surface of one of the layers, but it was in an imperfect state.

On approaching Livermore's valley, or rancho, we left the main road and crossed over low hills on the left. Outcrops of soft, earthy sandstones were frequently seen. At one point the trend was north 30° west, and the dip northeast, at an angle of 45°. Beyond this a reverse dip was found, and, to all appearance, an anticlinal axis. The strata were all light colored and contained a large amount of clay, and clay mingled with sand. In one stratum a large amount of pumice-stone was found disseminated in irregular masses, from one-quarter of an inch to several inches in diameter. It was white and very soft and fibrous, the cells being nearly all in one direction and elongated.

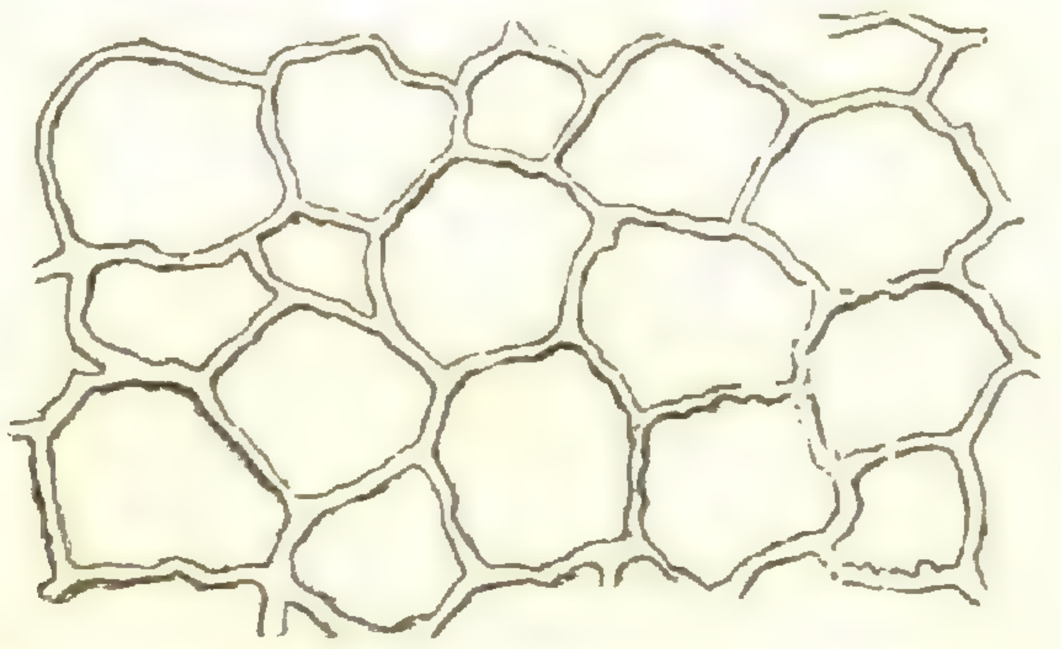
This formation of sandstone and conglomerate, which was so constantly seen, is, apparently,

continuous from Martinez southward to Livermore's pass, and beyond it. It probably forms the basis of all the rounded hills along the valleys already followed by the Expedition. Wherever the strata appear, they are highly disturbed, the angle of dip being generally over 45°. The general or average trend may be said to be from 30° to 45° west of north and east of south. Several long ridges, presenting precipitous faces towards the southwest, were visible at the base of Mount Diablo; they were seen from a distance of several miles, but they apparently had the general trend of the hills we followed, from northwest to southeast, and were of stratified rocks.

Mount Diablo is probably of igneous origin, but I could not observe any plutonic or volcanic rocks along the road we traversed. The rugged character and loftiness of the peak indicate that it is composed of hard crystalline minerals. This view is supported by the character of the rock brought from near the summit, of which a specimen was obtained. It is a mass of crystals of diallage or bronzite, confusedly mingled together, but possessing all the characters of the mineral. It has a brown color and bronzy lustre, and cleaves very readily, with broad and brilliant faces.[1] It is common in serpentine, and it is most probable that this is the summit-rock of the mountain.

The soft sandstones and earthy strata forming the hills of the part of the route under consideration, are easily acted upon and worn away by the weather, and thus furnish the material for a deep and loose soil. This is readily acted upon by the rains, and smooth rolling hills result.

DEEP SUN-CRACKS IN THE SOIL.



The soil so produced contains a large amount of clay, and it shrinks so much by drying during the summer, that the surface is traversed in every direction by cracks and fissures, that are frequently two inches wide and sixteen or eighteen inches deep. Their character and form is represented by the figure.

When this deep soil becomes saturated with water during the long heavy rains of winter, these fissures close. At such times, an immense weight of water is absorbed by the dry soil; and when it rests on the sides of the steep hills, or upon an inclined surface of rocks, large bodies of the saturated earth become loosened by the great weight, and slide down in an avalanche of mud to the valley below. It is sometimes the case, that an area of fifty or one hundred feet in diameter, will break loose near the summit of a hill, and slide down over the surface below it without breaking the soil; but the production of a complete excavated track from the top to the bottom of the hill is more common. This tearing up of the soil prepares the way for a current of surface water, which soon wears deep ravines in the yielding materials.

The soil appears to be well adapted to the growth of grains. The hills are covered during the spring and early summer with a luxuriant growth of the wild oat; and wherever the valleys

[1] A large quantity of this rock was quarried a few years ago, under the supposition that it contained a large per centage of gold. If the same as the specimen I have, mere inspection by a competent geologist would have shown the fallacy of the belief, and saved much expenditure of time and money.

have been cultivated, heavy crops of wheat and barley verify this natural indication of the fertility of the soil. Many large fields of grain presented a beautiful appearance, and were being harvested by the aid of the patent reaping-machines.

The valleys through which we passed are mostly well watered, and are timbered with majestic oak trees, forming open groves free from any undergrowth.

The hills are usually free from timber of any kind, but an occasional ravine or side valley, that is sheltered from the high winds or is watered by a spring, sustains a growth of oaks.

Wherever the trees of that region are exposed to the prevailing wind from the coast they become bent over to one side, and show the effect of the wind in a most remarkable manner. It is not uncommon to find trees growing almost horizontally along the ground. All the degrees of inclination and peculiar forms shown in the annexed wood cut were observed.

EFFECT OF THE PREVAILING WIND UPON TREES.

Livermore's Valley.—We reached Livermore's on the 13th of July, and camped near the entrance to the pass called by the same name. This valley is a widely extended plain, looking at this season perfectly brown and barren, and yet it is covered in places by droves of cattle apparently well fed. It is several miles in length and breadth, extending between the range on the west, which separates it from the valley of San José, and the low range on the east, through which Livermore's pass conducts to the broad valley of the San Joaquin. The mountains on the west side appear high, and are perfectly brown and nearly treeless. A double line of summits is presented to the view, as if there were two lines of elevation. A long line of trees, which appear very small in the distance, is visible at the base of the range and on the margin of the plain. Near the camp, there is a range of low hills, their elevation, as shown by the aneroid barometer, being one hundred and fifty feet. There is no indication of strata ; the surface is covered with a thick coating of gravel and pebbles, apparently the deposits of a stream. The soil is loose and poor, and does not appear to sustain the usual growth of the wild oat. It is reported that "fossil oysters" occur in this valley, but the locality was not found.

Livermore's Pass, July 16.—The entrance to the pass is among low rounded hills, and the road follows the circuitous windings of the narrow valleys between them. These hills increase in altitude towards the centre of the range, and have very steep slopes. This range of hills extends from Mount Diablo southeasterly, and is the last or most eastern of the Coast Mountains, and borders upon the plains of the San Joaquin river.

The rocks along the route were stratified, being chiefly sandstone and conglomerate. No other formations were observed. These sandstones rarely appear above the surface of the hills, being covered with a soil that is apparently derived from their decomposition. Natural sections along the streams, favorable to the observation of the characters of the strata, were also rare. I was, however, able to determine that the strata are inclined in various directions, and at angles varying from 30° to 50°. The prevailing trend is northwest and southeast. The sandstone is more firmly consolidated than that at Navy Point and at Martinez, and more nearly resembles the rock quarried at Benicia for buildings.

A stratum of conglomerate forms a prominent feature of the rocks of Livermore's pass. It appears at intervals in the form of huge outliers, apparently unconnected with any substratum of rock. It is similar to that observed at Benicia, and is probably a continuation of the same bed. A westerly dip of about 20° was observed at one of its outcrops. One of these outlying masses is composed chiefly of pebbles, of the size of beans or peas, but firmly cemented together, so that masses could be broken off by the hammer. At other places large stones and pebbles were seen. At one of the principal outcrops of this character the upper part of the mass is a thick bed of compact sandstone, and under it a second bed enclosing pebbles of quartz and a large round fragment of compact, fine-grained limestone, resembling that used by lithographers. The sandstone above also contains round masses harder than the rest of the rock, but probably concretionary. They do not weather as rapidly as the surrounding rock, and stand out from it in relief. The foundation on which the layer of sandstone rests appears to wear away most rapidly, and the rock is thus left projecting above, and far enough to afford the traveller protection from the weather, the height of the whole being about thirty feet. At the base of this curious rock there are several cylindrical or conical cavities in the stone, about six inches in diameter and eight to ten deep. They are perfectly smooth at the sides and bottom, and were probably formed by the Indians for pounding their barley.

About a mile east of the summit an outcrop of sandstone in the side of one of the hills contained numerous globular or spherical masses of sandstone, two or three feet in diameter. They are harder than the surrounding portions, and appeared to be the result of concretionary action rather than to be due to the decomposition of angular blocks. A small outlier of this description is represented in the figure.

CONCRETION AND ARCH OF SANDSTONE.

The sandstone adjoining the spheroidal mass has worn away so as to leave an arch, so perfect as to appear to be the work of art rather than the result of decay.

Outcrops of the strata became more common on the eastern side of the pass, and were of greater extent, but not so high and imposing. One of the exposures consisted of a bed of sandstone, weathered into fanciful forms—columns, spires, and sharp points. It is underlaid by a coarse conglomerate, and the pebbles which have been loosened from it cover the surrounding surface.

The slopes of the hills on the eastern side of the range are more gradual and gentle than on the west; this is also the case with the dips of the strata, which vary from ten to twenty degrees.

While the surveying party were measuring the pass, and taking barometrical observations, I travelled up one of the side ravines towards the north, and found everywhere the same characteristic steep, but rounded, hills and barren surfaces.

This barrenness, however, was only apparent. The season of green grass and flowers had passed, and fires had swept over the region, burning all the straw of the wild-oat and the stalks

of weeds. But on close inspection of the bare surface, the grains of oats could be perceived scattered about, or collected in little depressions, sheltered from the wind. The fire, it seems, is not hot and lasting enough to accomplish more than the separation of the kernel from the husk; perhaps parching its surface or hull. In this condition, it is fitted to fall into the cracks of the soil, and thus be entombed in readiness to spring up after the first shower of winter, or to afford sustenance to birds and bands of deer or elk. That it is sought and eaten by deer while in this state I had full evidence, for I came upon a herd quietly feeding on a spot, which, at a distance, seemed to be only the bare and blackened earth.

In the endeavor to cross back to the valley of the Pass, without retracing my steps, I mounted to the summits of several of the hills. On nearly all sides there seemed to be no limit to their succession ; one rounded outline was seen beyond another far into the distance, and all were of the same brown or yellow hue, without a green tree or shrub. But looking eastward, towards the San Joaquin, a far different view was presented. There lay outstretched the broad and green Tulares—great swamps or lowlands overgrown with rushes and threaded by the sinuous channels and sloughs of the river. The further margin was hid in the smoky distance, but this served to increase rather than diminsh the conception of the great extent of this alluvial tract.

We encamped at a place called Elkhorn, consisting of one or two rudely constructed houses, at the base of the low hills on the east side of the range. The place probably derives its name from the number of the antlers of the elk found here and among the surrounding hills. In this vicinity several thick beds of drift-gravel and rounded boulders, six, eight, and ten inches in diameter, were observed. During the night we experienced a violent wind, which became a gale towards morning, and we were glad to roll up our blankets and put on overcoats, the morning was so cold.

Elkhorn to Grayson's ferry, San Joaquin river, July 18, 30 *miles.*—We again turned southward, and travelled between the base of the Diablo range and the left margin of the marshes and tulares of the San Joaquin river. For the greater part of the distance the surface is nearly level, and is almost a desert plain, consisting of gravel and pebbles brought down from the hills. Some of the streams that descend from the Diablo range excavate wide and shallow gullies in the plain, and leave them strewn with rounded boulders of various sizes. At this season these gullies are without water. All this portion of the route is admirably adapted to the construction of a railroad. The gravel will form durable embankments, and can be readily excavated, but no cuttings will be required.

The mountains of the Diablo range were constantly visible on our right, and here and there a distinct outcrop of sandstone could be seen, the dip generally appearing to be southwest. A part of the surface of the plain was covered with a growth of sunflower, standing from six to ten feet high, and the blossoms very small.

The lower part of the San Joaquin river is bordered by numerous sloughs, and winds about through low marshy ground, covered with rushes and willows. Such portions of these marshes as are only temporarily overflowed, during the winter months, support a growth of coarse grass and other plants. In some places along the margin of these sloughs the soil is fine and deep. It appears rich in the inorganic constituents of plants, but is deficient in organic materials.

The number and intricacy of the winding sloughs and channels that traverse this wide area of low marshy land is worthy of notice. They are well shown upon the general map. The whole included area may be regarded as the alluvium of the Sacramento and San Joaquin rivers, and as an extensive interior delta.

CHAPTER II.

GRAYSON'S FERRY, ON THE SAN JOAQUIN, TO FORT MILLER.

San Joaquin river at Grayson's ferry.—Tuolumne river.—Alluvial land under cultivation.—Mitchell's bridge.—Terraces.—Dry creek to the Merced river.—Outcrops of sandstone.—Merced river.—Drift of erupted rocks.—Merced river to Bear creek.—Table hills.—Horizontal strata.—Fossil tree.—Foothills of the Sierra.—Granitic and metamorphic rocks.—Clay slate.—Quartz veins.—Gold.—Sandstone strata resting on the edges of the slates.—Quartz veins.—Iron ore.—Burns' creek.—Flat-topped hills.—Bear creek.—Section of the horizontal strata.—Sun-cracks in the strata.—Andalusite.—View of the plains of the San Joaquin.—Gold.—Metamorphic rocks and quartz veins.—Little Mariposa river.—Oppressive heat of the plains.—Mariposa river to the Fresno.—Granite.—Metamorphic rocks.—Chowchillas river.—Section.—Stratum of conglomerate.—Slate containing andalusite.—Sand and drift of the Chowchillas.—Plains between the Chowchillas and the Fresno.—Snow on the Sierra.—Fresno river.—Rich soil.—Granite.—Syenite.—Gold.—Table-lands covered with lava.

Grayson's Ferry, July 18.—We crossed the San Joaquin at this ferry and landed on the eastern bank a short distance below the mouth of the Tuolumne river, which enters the San Joaquin from the eastward. Both banks of the river are low, and the western side is fringed with a fine grove of trees. The opposite side is, however, without timber, and the soil appears to be poor and sandy, supporting only a scanty growth of grass and weeds.

At the time we crossed the river the water was not at its lowest stage, the stream being still swollen by the melting of the snow on the peaks of the Sierra Nevada. A large portion of the bottom-land of the river was therefore submerged, and the stream was much broader than is usual in the dry season. The current was swift and strong, and considerable quantities of fine sand and mica were suspended in the flood.

Tuolumne river.—Leaving the San Joaquin, we passed eastward along the south side of the Tuolumne and a short distance from its left bank. Its course over the plains was distinctly marked by the green timber along its bottom-land, and we encamped on its borders in a splendid grove of oaks. The size and beauty of these trees, and the luxuriance of other vegetation, bore testimony to the depth and richness of the soil, and its adaptation for agriculture. This vegetation and timber is confined to a bench or terrace of the river, lower than the upper or barren plain, and yet slightly raised above the bed of the stream. The height of the surface of the plain above the river-bottom, or its first terrace, is variable. It was not clearly defined at our first camp, but, at the second, about 30 miles above the mouth of the river in the San Joaquin, it was about thirty feet high, and as we travelled up the stream I observed that it increased to a height, at one place, of nearly one hundred feet.

The low river-bottom, bounded by the bank or terrace, is of variable width, and portions of it are cleared and cultivated. It is sometimes slightly overflowed during the season of floods.

The regularity and the steep slope of the terrace are remarkable, the descent being often so abrupt as to be impassable. These valleys, filled with green vegetation and trees, present an agreeable and striking contrast with the broad and nearly desert plains that they traverse.

Mitchell's bridge, July 20.—We descended from the plain to the bottom-land of the river and camped. We found a wide belt of fine land under cultivation; corn, vegetables and

melons were abundant. At this point on the river there were evidences of three distinct terraces, rising one above the other at heights of about fifty feet each. The upper one is much cut and furrowed by rains, and now forms a succession of low rounded hills. These hills consist of sedimentary, argillaceous sandstones, and the strata present various shades of color, changing from white to pink and bluish. Beds of white clay were observed, and layers of pebbles.

Dry creek to the Merced river.—Ten miles from the camp at Mitchell's bridge, we entered the valley of Dry creek; and I here observed, along its banks, horizontal strata of argillaceous sandstone in a soft, unconsolidated state. A house has been built of this soft clayey rock, and the blocks have since become hard and stone-like in texture. Outcropping edges of nearly horizontal beds of compact sandstone, similar to that of the Diablo range at Livermore's pass, were also observed. It is associated with a very coarse conglomerate, or a mass of large pebbles and cobble-stones cemented together. These strata appear to be of tertiary age, but no fossils were found.

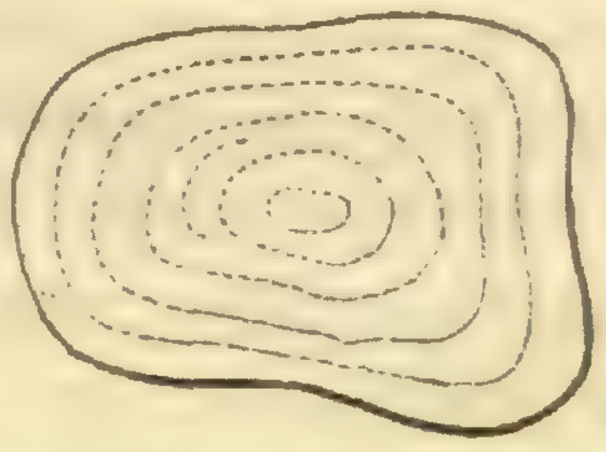
Merced river, July 21.—Horizontal strata of argillaceous sandstone were observed in descending from the plain into the valley of the Merced river. At the time of crossing, the stream was clear and pure, and the temperature of the water was found to be 72° F.; air 86. The bed of the stream was paved with water-worn boulders, almost all of basaltic and granitic rocks. The basaltic fragments were predominant; and from their quantity and general similarity, I was led to conclude that the stream must traverse an extensive region of erupted rock high up in the Sierra.

From the appearance of the bed of this river, and the wide margin of transported rocks, and banks of pebbles high above the water at the time we crossed, it is evident that it sometimes becomes a rapid and powerful torrent.

Merced river to Bear creek, July 22, 18.3 *miles.*—After leaving the Merced our route lay among numerous isolated hills with flat summits; a group of which is represented in outline in the figure.

TABLE HILLS NEAR THE MERCED.

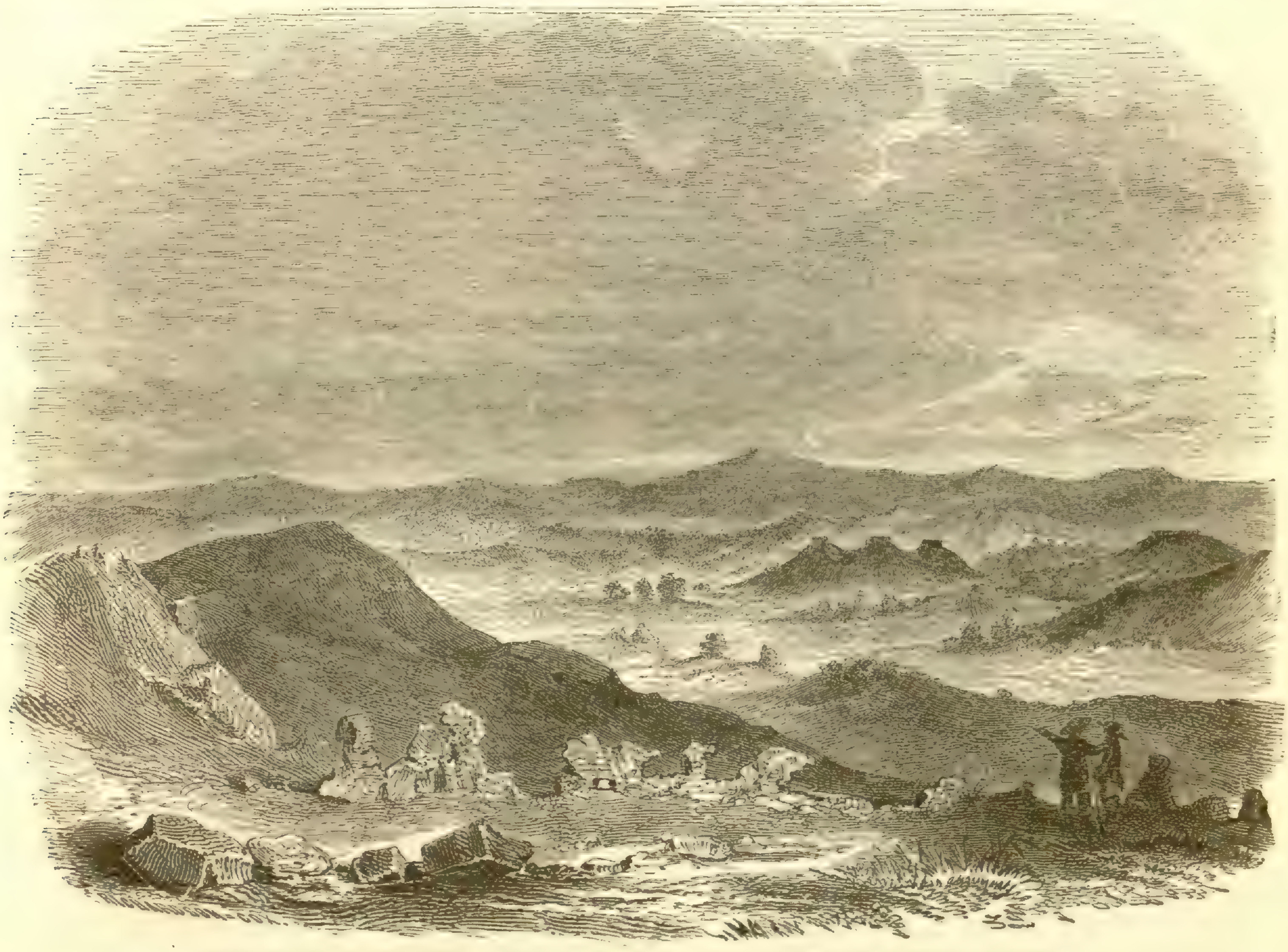
These hills were estimated to be about one hundred feet in height. They are formed of horizontal strata, and are the remnants of a former plain, the intermediate portions having been removed by denudation. The "cap rock" on one of the hills was found to consist of a bed of conglomerate, chiefly of quartz pebbles, underlaid by a bed of light-colored sandstone, and a



FOSSIL TREE.

second stratum of conglomerate. A cylindrical object, like a log of wood, was protruding two feet beyond this layer of sandstone, and it proved to be a part of a fossil tree, with a cross section like the figure.

It was somewhat flattened as if by pressure. Its outer portions had evidently been bored into by worms, as cavities similar to those formed by the Teredo were found filled in with sandstone. The whole mass was highly charged with peroxide of iron, which, indeed, seemed to be the chief constituent.

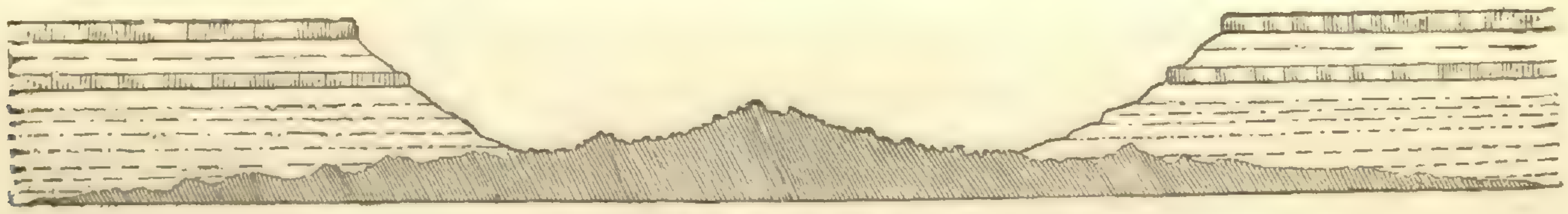


FOOT-HILLS OF THE SIERRA NEVADA, BETWEEN THE MERCED AND MARIPOSA RIVERS.

We had now progressed so far towards the mountains that we were no longer upon the broad plains of the great valley of the San Joaquin, but were travelling among the foot-hills of the Sierra Nevada. Our route from this point, southward to Fort Miller, lay nearly on the border of the lower granitic ranges, which presented occasional opportunities for examining them, in connexion with the sedimentary foot-hills.

The first outcrop of any of the rocks of the granitic and metamorphic series met on the survey was near Howard's ferry, on the Merced. At that place extended outcrops of dark colored clay slate were observed, having a trend N. 55° W., and an inclination of 70° towards the east. In some places they appeared chloritic; and in others had the general character of roofing slate. They were traversed, in the direction of the bedding, by quartz veins of great thickness, the white quartz contrasting finely with the black slate. This place is only nine miles west from Quartzburg, where several mining companies have erected crushers and stamps for pulverizing the quartz and extracting the gold it bears. The unconformability of the sedimentary sandstone formation with these roofing and chlorite slates is strikingly shown in this vicinity, where streams have cut so deeply as to expose both formations. The horizontal strata rest upon the upturned edges of the slates, as is shown in the section.

The outcropping layers of hard sandstone were visible in the hills on each side, the intermediate portion (between the hills) having been removed by denudation. At the highest part of the outcrop of slates, a quartz vein, five feet thick, stands out above the general surface, and



UNCONFORMABILITY OF SLATES AND SANDSTONE.

forms a wall-like mass of fragments. These, being milk-white, contrast strongly with the black slate on each side. This quartz has preserved the surrounding slate from abrasion by currents of water, and thus it stands at the summit of a little eminence.

Numerous continuous outcrops of quartz veins of great thickness could be seen on the slopes of the higher ridges, several miles distant. Even where the surrounding rocks were buried in soil, the presence of the veins was shown by great loose blocks of the quartz lying in long lines on the surface.

A quartz vein outcropping near "Burns' creek" was associated with a bed of compact hydrated peroxide of iron, the whole being nearly twenty-five feet thick. The quartz was much stained with iron, and the whole outcrop presented a dark chestnut-brown color, except where

REMNANT OF A STRATUM OF SANDSTONE.

covered with mosses and lichens, these being of the most brilliant and various colors. Large blocks of the iron ore, and slate permeated with it, were lying around the outcrop; many of the

masses being five or six feet in diameter. The ore breaks with a smooth conchoidal fracture, it being singularly compact and hard. It occurs interleaved with the slate, portions of the rock being found in the ore.

This bed of iron oxide appeared to be the result of the decomposition of pyrites; and if so, the undecomposed pyrites would be reached by sinking to a sufficient depth in the vein. It is probably auriferous, but no gold can be seen in the oxide of iron or quartz. It may, however, exist in quantity sufficient to pay for working. This vein conforms in trend and dip with the slates, which resemble those in the gold region of North Carolina and Virginia.

Burns' creek.—A remnant of the former elevated plain of sandstone formed a picturesque object near our route, and was sketched by Mr. Koppel.

It consists of a nearly circular disk of compact sandstone, ten or fifteen feet thick, capping the summit of a round mound. Hills of this character, of greater extent and elevation, are numerous for several miles south of this point.

Bear creek.—At Bear creek, twelve miles north of the Mariposa river, a good natural section or vertical exposure of the strata composing one of these flat-topped hills was presented. It consisted of a series of beds of coarse and fine sandstone and strata of gravel and conglomerate, which are represented in section, Chapter XIII. The whole elevation of the hill was estimated to be about 150 feet. The following is the succession of the strata as observed from the top downwards to the level of the creek. The thicknesses are given as they were estimated, and are, therefore, merely approximate. The letters refer to the section.

SECTION OF THE STRATA AT BEAR CREEK.

k. Conglomerate	6 feet.
j. Sandstone	50 "
i. Conglomerate	22 "
h. Sandstone, fine	1 foot.
g. Conglomerate of gravel, white and black quartz, and nodules of carbonate of lime	10 feet.
f. Sandstone, showing diagonal stratification and one or two layers of gravel	12 "
e. Sandstone, with a layer of pebbles	3 "
d. Hard sandstone, thinly bedded; layer of pebbles towards the base	20 "
c. Compact sandstone, with some small pebbles	2 "
b. Sandstone, with coarse grains and pebbles	1 foot.
a. Sandstone	—

The upper stratum is perfectly level on the top and free from soil; a dwarfed bush or tree, here and there, is the only vegetation. The whole surface appears fissured, or as if cracked by drying in the sun—precisely as the soil is cracked during the dry season. This must have taken place at the time of the deposition of the rock or soon after. On closely inspecting the slight accumulations of fine gravel in some of the hollows of the rocks, numerous very small but beautiful crystals of andalusite were found. These did not exceed three-sixteenths of an inch in diameter, and were seldom over one-eighth. They are translucent, but appear to be worn and rounded by attrition.

From the summit a fine prospect was presented towards the south. The broad valley of the San Joaquin was in full view, and it was dotted by numerous isolated flat-topped hills, standing like islands in the plain. Bear creek was entirely dry at the point we crossed; higher up the stream, in the hills, large quantities of gold have been obtained, and the stream is noted for the number and magnitude of the nuggets it has produced. The gold is not evenly distributed; it is found only at intervals, as might be expected from the size and weight of the masses. For this reason the diggings are called *spotted* by the miners.

From the hill at Bear creek to the Mariposa river the road passes over the border of the metamorphic rocks, and an occasional quartz vein is seen. The earth is also more or less colored by oxide of iron, and fragments of quartz are numerous. These indicate the presence of gold. Rounded hills, with flat caps of sandstones, continue in view. They are of various altitudes, but below 200 feet.

We arrived at camp on the Little Mariposa about six in the afternoon of the 22d; the thermometer standing at 96 degrees in the shade, and a breeze blowing. The heat of the sun during the day on the broad, open plain was intense and oppressive. The bed of the river is now dry, except in the deep and shaded places.

Mariposa river to the Fresno river, July 23, 22.5 *miles.*—We left camp at 2.30 a. m., and about five miles south of it passed upon granitic or metamorphic rocks, both compact and gneissose, containing beds of mica and hornblende slates. These have a trend of N. 60° W., dip 75° N.E. The granite, at a short distance, resembles syenite, but it is composed of feldspar and mica, with some quartz. It decomposes rapidly into a granular mass. The beds of a slaty character were very thin, being not over one foot in width; narrow and irregular quartz veins were also observed.

Chowchillas river.—The denuding action of rivers, and their power to cut a bed downwards through the sedimentary rocks, is well shown on the Chowchillas on the left side of the ford. At that place, hills with broad, flat tops rise abruptly to an equal elevation on each side of the stream.

SECTION AT THE CROSSING OF THE CHOWCHILLAS.

They are peculiarly interesting, as they contain a bed of conglomerate fifteen feet thick; of pebbles and round masses of *white quartz*, some of them twelve inches in diameter. They are all rounded and smooth, showing that they have been much rolled and waterworn. This stratum forms the protecting layer on the tops of the hills, the pebbles being firmly cemented together, and offering resistance to decomposition. The softer sandstones underlying it are more rapidly worn away, and allow large masses of the conglomerate to fall off and roll down the slope.

Fragments of slate-rock, enclosing large numbers of crystals of andalusite, were intermingled with the quartz; and detached crystals of this interesting mineral, of unusual size, were abundant.[1] The cementing material of the mass was sand and sesqui-oxide of iron, the latter being in quantity sufficient to give a dark color to the matrix.

This peculiar conglomerate, together with the contiguous beds of sandstone, project from the tops of the hills at the same height on both sides of the river; rendering it strikingly evident, even to the most ordinary observer, that the strata were once continuous. Similar phenomena are presented all along the slope of the Sierra Nevada, wherever the streams have cut through the horizontal sedimentary sandstones.

At the point where we crossed the Chowchillas, below the hills just described, its banks are low and sandy, and a broad but shallow current was running over a bed of fine sand filled with small glittering crystals of brown mica. There was very little river-drift of rounded stones or

[1] These crystals of andalusite are described in Chapter XX.

CROSSING OF CHOWCHILLAS RIVER.

gravel in the channel, and appearances indicated that at that point the river seldom flowed as a tumultuous, rapid torrent. I found numerous large and good crystals of andalusite in the sand of the banks, and some fragments of slate, also full of crystals. These may have been washed out of the adjoining conglomerate, or transported from the original sources in the Sierra Nevada.

Chowchillas to the Fresno, 12 *miles*.—From the Chowchillas to the Fresno river, outcrops of horizontal strata, forming low bluffs, were constantly visible. The surface is formed of sand and gravel derived from the degradation of the surrounding sandstone hills. It is almost destitute of vegetation, and free from moisture. The reflection of the sun's rays from this arid surface is exceedingly oppressive; especially when the thermometer indicates a temperature of 100° in the shade. It stood at this point during a part of the day. At the same time, the snow-capped summits of the Sierra Nevada presented a splendid appearance, with their white mantles glistening in the sun; and, although far distant, they appeared to lend a refreshing coolness to the air of the plains.

Fresno river to Fort Miller, on the San Joaquin river.—The high peaks of the Sierra Nevada, white with snow, were visible from our camp in the plain. At this place and season the river ceases to flow in a continuous stream, and water is only found in the deep holes of the channel.

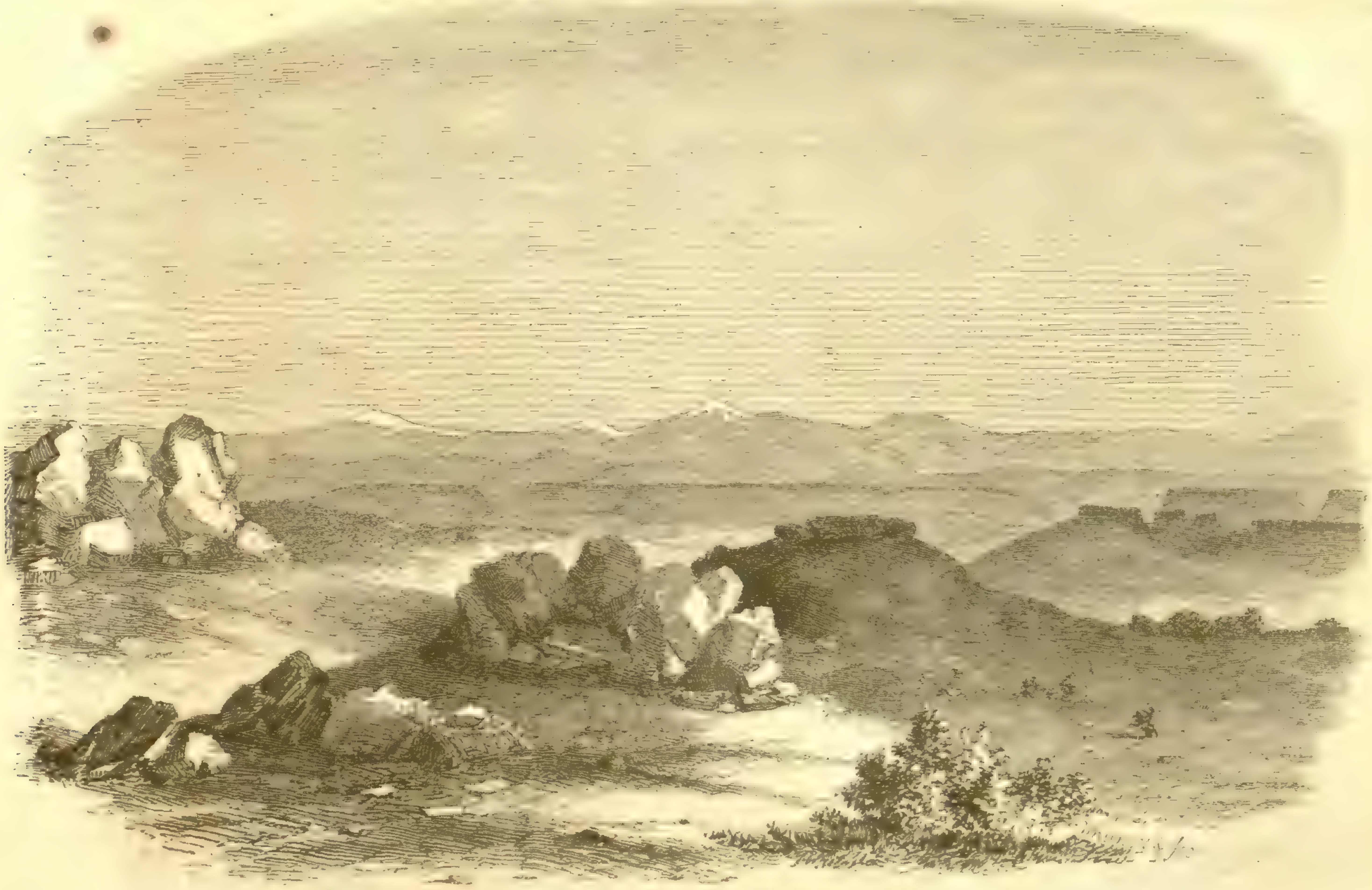


TABLE-HILLS NEAR FORT MILLER

Drs. Haller and Leech have a farm on the banks, where they have raised thousands of bushels of barley; the spontaneous or second crop averaging thirty bushels to the acre.

Leaving the camp and the party, I passed up the stream for several miles, over a succession of outcrops of grey, compact granite. The channel of the river is narrow and rocky, and filled with huge blocks of granite detached from the ridges.

About eight miles from camp, in an easterly direction, I observed a peculiar porphyritic syenite that apparently underlaid the granite, and gave indications of being more recent in age. The exposure was so slight at this place that sufficient evidence on this point could not be obtained.

Many miners were at work at different points along the stream washing the gold out of the sand with a common cradle. It was stated that they could not make much more than their expenses ; nearly all the gold they obtained being traded at a neighboring store for provisions and goods. The gold is in fine scales ; higher up it is much more coarse, and in large grains and masses.

Leaving the stream, and travelling south towards the San Joaquin, I passed over a succession of granite ridges for fifteen miles, following Indian trails. These ridges were thinly covered with oak and pine trees. The narrow valleys or gulches between them were entirely dry, but are evidently traversed by brooks during the rainy season. Gneissoidal granite, passing into a coarse mica slate, traversed by quartz veins, was passed just before reaching the San Joaquin river, about two miles below Fort Miller.

During this day's ride numerous table-hills or mesas were seen on the right, but several miles distant, and apparently out upon the plain. They were also observed by the main party in their transit from the Fresno to the San Joaquin along the plain, and a sketch was made by Mr. Koppel.

The mesas appeared to extend far up towards the high mountains, which, towering in the distance, were white with snow. The cap-rock of the hills was remarkably even and flat, and subsequent exploration showed that it was composed of hard, basaltic lava overlying soft strata, probably Tertiary

CHAPTER III.

FORT MILLER AND THE VICINITY—FORT MILLER TO OCOYA CREEK.

Granitic hills.—View of the valley of the San Joaquin.—Diurnal rise and fall of the water.—Temperature.—Salmon.—Terraces.—Gold.—Granite.—Lava-plain.—Nature of the rock.—Minerals in parallel planes.—Strata of volcanic materials under the basalt.—Origin of the lava.—Valleys of erosion.—Ancient rivers and water-falls.—Indians.—Millerton.—Climate.—Fort Miller to King's river.—Fort Miller to Dry creek.—Terrace.—King's river.—Sierra Nevada.—Sharp slate ridges transverse to the Sierra.—Outline view.—King's river to the Four creeks.—Alluvial clay.—Four creeks.—Luxuriant vegetation.—Irrigation.—Lost mountains.—Metamorphic rocks.—Quartz rocks.—Effects of the snow-peaks of the Sierra on the climate.—Four creeks to Moore's creek.—Carbonate of magnesia.—Moore's creek to White creek.—Auriferous rocks.—Trap.—White creek to Pose or Ocoya creek—Tertiary formation at the base of the Sierra Nevada.

On arriving at Fort Miller, a settlement and military post on the left bank of the San Joaquin, we encamped for several days, and thus an opportunity was presented for the examination of the geology of the immediate vicinity. The river flows in a deep winding valley, between high granitic hills, partly wooded with oaks and pines. The slopes of these hills are very steep;

VALLEY OF THE SAN JOAQUIN AT FORT MILLER

and a short distance above the fort they rise abruptly from the stream, leaving only a narrow "bench" or level area at their base. At the fort, this terrace or plain attains a considerable width, and several miles below opens out upon the broad plains of the San Joaquin.

The plain is shaded at intervals by groves of oak trees, some of them overhanging the river, thus forming a desirable and beautiful camp ground. The river was not at its highest stage at the time of our visit; but a l rge body of water was flowing in the channel, and it was evident that a considerable quantity of snow remained in the mountains at the sources of the river. A diurnal rise and fall of the water was constantly observed, and is, without doubt, produced by the melting of the snow during the day. This water was remarkably pure and clear, and very cold; its temperature seldom rising above 64° Fahrenheit, while that of the air varied from 99° to 104° in the shade. A difference of over forty degrees between the temperature of the air and the water is not uncommon, and it becomes very evident when bathing in the stream during the day. The Indians who live on the banks of the river do not, however, seem to regard this difference of temperature as sufficient; for it is their custom to prepare themselves for their bath by a preliminary baking in large underground huts, which have only one aperture, fronting the stream. A fire being built in the centre of the apartment, the Indians crowd around it, and frequently add to the humidity of the atmosphere by pouring water on heated stones. After a violent perspiration is thus produced, they rush into the river with much gratification.

During our stay at this camp we purchased fresh salmon of the Indians, who catch them in the river. It is probable, however, that they are not abundant, as the mining operations along the upper part of the stream and its tributaries sometimes load the water with impurities.

Although the river was not at its lowest stage, it flowed only in the deepest part of its bed, and left bare and dry a broad "bench" of gravel and sand which is completely covered at high water. Portions of the river-bed above the fort are obstructed by great numbers of large blocks of granite, similar to that found below the fort. The floods of the river have swept over these masses, and rounded their surfaces until they are smooth and bright.

River terraces.—Remains of ancient terraces are visible on both sides of the river, and may be recognized in the wood cut. These terraces appear to be three in number, and are at elevations of about thirty feet each. The third or upper terrace is obscure, and they are all much cut away and disguised by side ravines.

Gold is found in the bed of the river in considerable quantity. It is mostly very fine scale gold, and it is difficult to separate it from the black sand, which is abundant and heavy. Groups of gold-washers and Chinamen were engaged all along the banks, either washing out the gold in a common pan or using the "cradle." A pan-full of sand and gravel taken up anywhere on the surface of the first bench of the river, would "show color" on being washed out. This term *color* has passed into general use among the miners, denoting the presence of just sufficient gold to be well recognized. One of the miners was working his claim with a cradle, and employed two Indians to dig and bring the auriferous earth and gravel. He was obtaining about one ounce per day.

Some of the officers of the army at Fort Miller were constructing a canal along the bed of the stream, into which they were intending to turn the water of the river when at its lowest stage, and thus be enabled to obtain the sand of its bed, which was supposed to be extremely rich in gold.

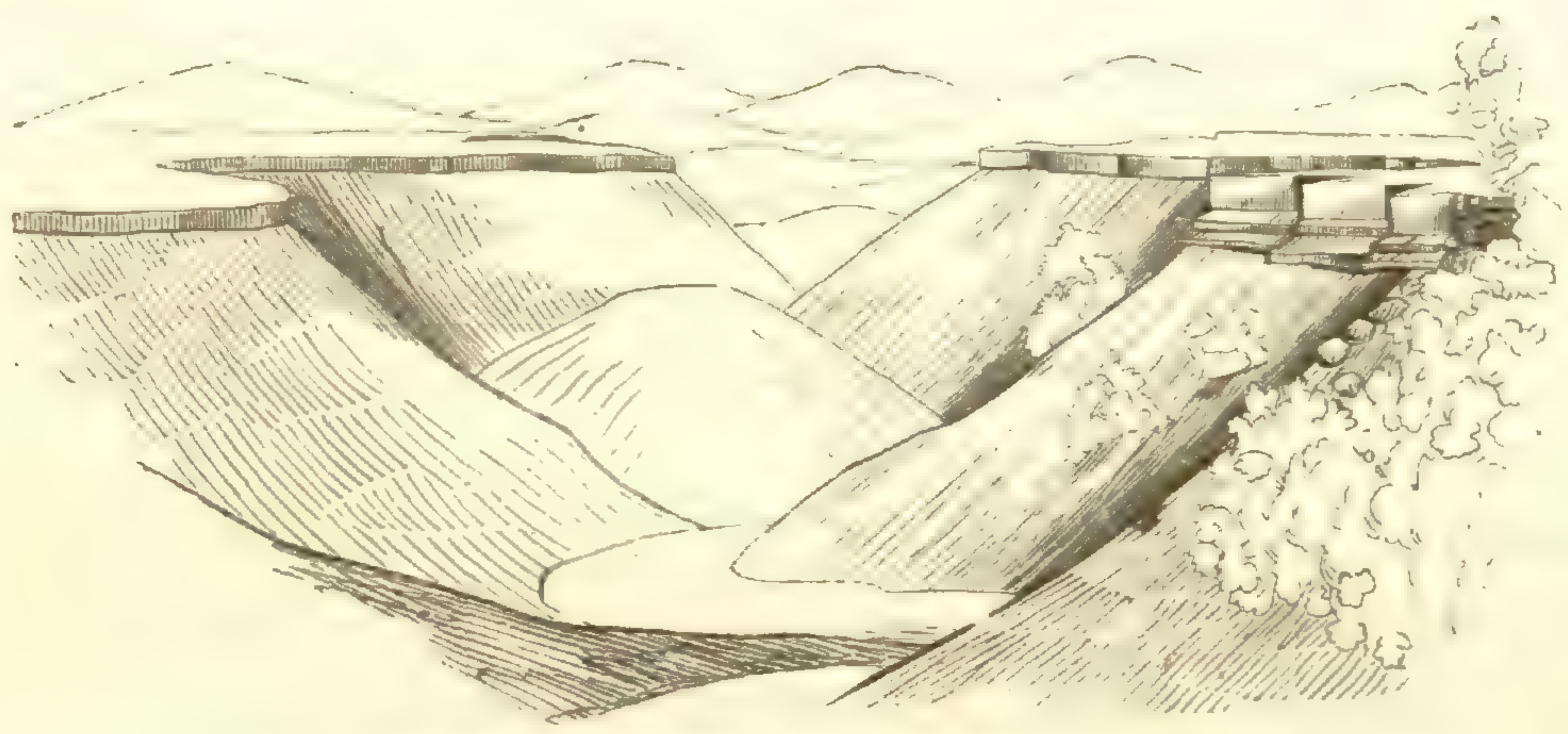
Granite.—Compact and granular granite is abundant in the vicinity of this place, and forms high ridges on both sides of the river. A specimen taken from a road-cutting just below the fort shows a fine grain and even distribution of the composing minerals. A portion of mica is replaced by hornblende, and the aggregation may be called a syenitic granite. It is an excellent building stone.

About one mile up the river above the fort, the granite passes into gneissoidal and slaty beds containing much hornblende. These beds all have a trend of N. 40° to 45° W., and they dip to the eastward at a high angle. The slaty masses alternate with the more compact and harder granite. This difference of mineral constitution and aggregation of the rock causes it to wear away unequally, and portions of the hills are rapidly decomposing under the influences of the weather. They thus cover their steep slopes with a rich soil, which sustains a growth of oaks and pines.

View No. 1, forming the frontispiece to the report, shows a valley between the granitic and metamorphic hills on the north side of the river. The sharp edges of the gneiss or mica-slate stand out from the surface in many places in large tabular masses.

Plain of basaltic lava.—Near the fort, one of the granite hills that rises to an elevation of about one thousand feet above the river is capped by a horizontal layer of compact basaltic lava about one hundred feet thick. It presents a bold escarpment fronting the valley, and from below looks like a grand fortress with vertical walls and rounded bastions.

On ascending the summit of this rock, it is seen to extend for great distances, apparently in a perfectly level plain miles in length and breadth. It borders the San Joaquin in its circuitous course for many miles; and continuations of the same broad field can be seen on the opposite side of the stream. A partial bird's-eye view of a part of this lava plain is presented in the wood-cut. The sketch was taken from the edge of the plain above the military station, and includes the gap through which the San Joaquin flows. The summit of the Sierra is shown in the distance.



ELEVATED PLAIN OF BASALTIC LAVA.

It will be seen from the engraving that the exposed edges of the sheet of lava do not in all cases present one continuous vertical wall, but rise in a terraced form, indicating the existence of three or more parallel sheets or layers, one superimposed on the other. These layers, or tabular masses of rock, exhibit, in a rude manner, the columnar structure, characteristic of similar igneous rocks. The weathered surface of this rock presents a rusty brown color; but the interior is black, and shows a crystalline structure. Loose blocks, when struck by the hammer, give a clear ringing sound, and break with a conchoidal fracture. Other parts of the rock were more scoriaceous, and filled with small cavities that do not appear to have contained minerals, but are probably air-cells. The rock is highly ferruginous, and affects the compass needle very strongly; in some places showing polarity.

In many parts of the surface I observed a distinct ridge-like character of the rock; there were distinct vertical planes, having a parallelism of direction, along which the rock cleaved with greater facility than in other lines. At other portions of the surface, that had been exposed to atmospheric changes for a long time, a distinct linear arrangement of the minerals was evident

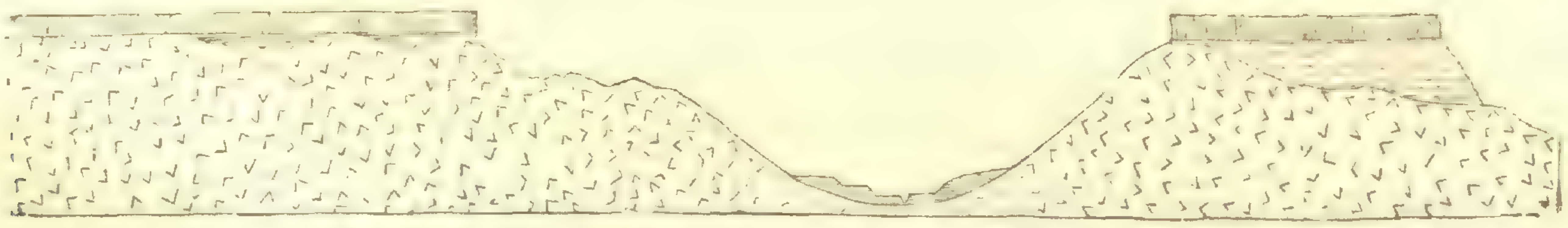
from the belted and striped character of the surface. Masses broken from this place verifi[ed] the surface indications; the imbedded crystals being found to be *arranged in parallel lines,* and with the broad tabular surface of the crystals all in *parallel* and *vertical* planes. This linear arrangement of minerals in volcanic rocks, and especially their occurrence in *vertical* planes in horizontal beds or sheets of basalt, is exceedingly interesting, as it tends to throw light upon the origin of the laminated structure developed in granitic rocks.

The path leading up to the surface of this table-land was along a valley at the southeast of the fort, and was accessible to mules. I was able, with a little difficulty, to get my mule up the cliff at a point where it was much broken down by weathering. I rode for several miles over the level plain without finding any obstruction or much soil to obscure the black floor of lava. The plain appeared unbroken far into the distance; but I soon came upon a ravine with abrupt sides, visible only when the brink was nearly reached, and was forced to return. The plain is, doubtless, intersected in this manner by ravines invisible from a distance, unless they extend in the direction of the line of vision. Looking off from the edge of this plain towards the San Joaquin, a long line of flat-topped hills was visible. These hills are, doubtless, portions of the table-mountain seen on approaching the river. The summit appears to have been continuous, and is intersected by gaps so as to form a series of flat-topped mounds, separated by little valleys. The original plain probably inclined gently towards the west, as an uniforn inclination is now distinctly visible in all the summits. The San Joaquin was seen winding around the southwestern point of this interesting range.

The immediate contact of the basalt with the subjacent rocks was not visible on the slope facing the San Joaquin. I ascended on that side and traced the granite nearly to the lower line of the basalt. The upper portions of the granite showed horizontal beds, differing in their mineralogical character; a portion was very coarse-grained and highly feldspathic, other portions were finely laminated, and with these was a bed consisting of large crystalline masses of albite imbedded in quartz. These rocks were, however, exposed for a short distance only, and may be portions of large granitic veins.

The general character of the granite in the vicinity and lower down the slope is compact and even in texture. On descending from the plain of basalt at the southern margin, I found that there was a vertical exposure of the edges of horizontal sedimentary beds underlying the basalt. These were composed of gravel, fine white sand, white clays, volcanic sand, and great masses of light and friable pumice stone. These masses were of various sizes, and formed layers over one foot thick. Volcanic material seemed to abound throughout the beds, and formed the principal part of their mass.

The whole thickness of the exposure did not exceed 100 feet, and a great part of it was so much obscured by soil that its character could not be satisfactorily determined. The relative positions of the basalt, sediments, and underlying granite, will be better understood by reference to the accompanying outline section, representing the bed of the San Joaquin and the hills on each side.



SECTION OF THE VALLEY OF THE SAN JOAQUIN AT FORT MILLER.

These underlying sediments are probably members of the same series that form the isolated

hills along the Merced and other rivers. They will probably be found to be of recent tertiary age. It is evident, from the fact of superposition, that the basalt is more recent in its origin.

In these extended igneous layers we have a remarkable and highly interesting instance of an immense overflow of molten rock, spreading itself out in a broad plain not less than fifteen or twenty miles in length and breath, and probably of much greater extent. Its compact and crystalline character, and the almost entire absence of that amygdaloidal, porous, and scoriaceous character peculiar to surface lava streams, indicate that it was subjected to pressure at the time of its overflow, and point to its submarine origin.

It may be difficult for those who are not familiar with the many examples of submarine overflows of lava, to conceive how this bed of rock could have spread itself out so uniformly over such a wide area, where we now find deep valleys and steep mountains, and scarcely a trace of any horizontal sedimentary rocks. This difficulty vanishes when due consideration is given to the ever-active and powerful denuding force of rivers and floods, and it is seen that the deep valleys and ravines that intersect this lava-plain have been excavated by their action.

The stratified sedimentary formations found lying horizontally under this lava indicate that the whole surface of the country was once overlaid by a continuous deposit of sediments in horizontal strata, which filled up all the valleys and inequalities in the original granitic surface, and thus produced a nearly level plain or slope of gentle inclination over what was previously a surface of rugged granite ridges. The inequalities of surface having been thus filled up by deposition, the overflow of fluid rock took place and spread out over the plain in an even layer. The stratified deposits are probably of marine origin, and may have been deposited at the bottom of a deep and quiet sea.

It was probably the case that the granite ridges were so high in many places that their tops were scarcely covered, and that some stood out above the general surface of the sedimentary layers. Thus, in some places, we find the lava in contact with granite; and again, it is underlaid by the sediments. It will probably be found that there are many places in this unexplored expanse of rock where the summits of the old granite ridges stand out above its surface like islands. Wherever this basaltic covering has been removed by denudation or otherwise, all the soft sediments, composed of exceedingly light materials, have been rapidly torn away by floods, and they are not now to be found except in some protected angle, and under the shelter of the projecting edge of the lava.

The existence of these soft strata, filling up all the inequalities of the ancient granite surface, and laying the foundation for this igneous overflow, has proved the main cause of its speedy downfall and decay.

The foundations of the rocky plain have been of sand, and wherever they have been exposed they have crumbled and been washed away, leaving great overhanging cliffs of lava to break off in successive masses by their own weight. Wherever the lava rests upon granite, the degradation of the plain appears to have nearly ceased, or to progress but slowly.

It is not impossible that this lava-plain was once overlaid by sediments similar to those now found under it. No remnants of such formations were found.

It should be remembered, that at the time when the present Coast Mountains were partly submerged, and held the same relation to the slope of the Sierra Nevada that is now sustained by the Farallones and other islands to the present coast, the plain of basalt was still partly beneath the depths of the primeval ocean; and that, during the period of elevation, the surf must have rolled for ages at the base of its dark cliffs, excavating deep caverns in the under-

lying soft sediments; producing, by this undermining process, the speedy degradation of the plain.

We must consider, also, that when the country was at a lower level, the rivers from the Sierra Nevada flowed over the surface of the lava; and that long before the newly risen continent was trod by the Mammoth and Mastodon, anterior to the advent of man, the San Joaquin commenced wearing its crooked channel, and poured its waters into the sea over the precipitous edges of the hard basalt. As the country gradually rose up, the clift was undermined; and during the lapse of ages the river must have cut its way backwards and excavated the present deep channel. It is thus probable that a series of magnificent waterfalls existed during the progress of this backward movement.

It has already been stated that a large quantity of the river-drift in the bed of the Merced river was composed of basalt. The headwaters of this stream are supposed to be near those of the San Joaquin; and I am informed that basaltic rocks form hills of great height in that vicinity. It is probable that these are a portion of the field of basalt just described, and they may be near or at the original source of the overflow. If this is so, it was probably above the level of the former sea; but the currents of lava that flowed from it may have reached the ocean and spread out in a plain on its bed.

It is difficult, and, indeed, impossible, to determine the former boundaries of this once igneous plain; it may have reached far out to the westward of its present limits, and extended over a part of what is now the Tulare valley.

The Indians collect about the fort in great numbers during the winter—as many as five or six hundred being there at one time. They live in the usual manner—in brush huts—a short distance below the fort. They make beautiful baskets or trays, of a strong round grass, which they weave so tightly and evenly that the baskets will hold water; and they are sometimes used to hold water while it is made to boil by throwing in heated stones. One mile below the fort is the ferry across the river. Here, there are several houses and shops; the place being called Millerton. The trade is chiefly with emigrants, miners, and the Indians. During our stay at this camp, Captain Love, at the head of a party of rangers, arrived, bringing with him the head of the notorious robber-chief, Joaquin Muerto. They had surprised Joaquin, with his party, in a pass of the Coast Range, and, after a short fight, shot him through the head.

The temperature of this valley or, at least, of our camp-ground, is worthy of note. Each day was like the preceding, and the unclouded sun seemed to have a remarkable heating power. The high hills on each side prevented a free circulation of air and reflected back the heat. The thermometer, during the middle part of the day, seldom indicated a temperature lower than 96 degrees F., and generally stood from 100° to 104° in the shade; in some localities 115°.

FORT MILLER TO OCOYA CREEK.

Fort Miller to King's river, July 31, 25.73 *miles.*—We left the San Joaquin at 4 a. m. of the 31st, and turned southward over low and rounded hills at the base of the mountains, and, after travelling about five miles, came to the plain of the San Joaquin or the Tulare valley. It is now more properly the Tulare valley, as the San Joaquin river, after leaving the foot-hills and coursing a short distance down the slope of the valley, turns northward and does not receive the streams which descend from the mountains further south. The valley or plain, however, appears continuous, and there is no visible line of separation between the two systems of natural drainage.

From the San Joaquin to Dry creek, about thirteen miles, the rounded hills were seen; and at one place a distant hill presented the appearance of a succession of terraces, which, however, may be the edges of a horizontal strata. In one of the hills limited outcrops of horizontal argillaceous beds and a conglomerate were found. The strata are probably similar to those underlying the lava at Fort Miller. The soil over the greater part of this distance was very good.

On arriving at Dry creek we met Senator Gwin, on his return from a visit, with several friends, to the Tejon Pass. The bed of Dry creek is shallow and sandy, and was entirely dry at the time we crossed; but it was evident that a strong current of water flows there at certain seasons. A short distance south of this creek there is a fine view of a long, low, nearly horizontal terrace, appearing to flank a projecting spur of the mountains. This long terrace appeared to be composed of regular and nearly horizontal strata; but a near examination could not be made. It is, doubtless, a portion of a former sub-marine slope.

King's River.—This stream, sometimes known as the Lake fork, flows down from the Sierra just beyond the terrace above described. Its course over the plain was marked in the distance by a long line of trees, just visible above the surface, the bed of the stream being sunk below it. We reached the margin of the bottom-land about sunset, and encamped upon a low gravelly spot which had recently been inundated by the stream. We here found a coarse swamp-grass, sun-flowers, and willows. As the sun went down the Coast Mountains were visible in the west, about sixty miles distant; and on the other side, the white, snow-capped summits of the Sierra. Many herds of antelope were seen during the day, and before dark one was brought in by our hunters.

The bottom-land and timber of King's river is said to be five miles in breadth at several parts of the stream after it leaves the mountains. A great body of water flows here, and all the sloughs are well timbered. It flows into the Tulare lake.

King's River to the Four Creeks, August 1, 40.4 *miles.*—We left the camp on the borders of King's river and travelled along its right bank to Poole's ferry, twelve miles below. The river winds about and appears to skirt the mountains, the banks becoming higher as we descend. The elevation was, however, variable. The descent from the general level of the plain to a running slough, near the first camp, was about eighteen feet; but at the ferry it was forty, and divided into two benches or terraces. Their general character is represented in the annexed section.

A short distance below the ferry this order is reversed, the single bank being on the opposite side. These banks consist of regular layers of argillaceous sandstone and clay, which is hard and rock-like when perfectly dry. The lowest stratum was principally of clay; and the whole deposit had a modern and alluvial appearance.

From the banks of the river, at this ferry, there is nothing to obstruct the vision across the whole breadth of the Tulare valley; and the Coast Mountains may be dimly seen rising above the limits of the far-stretching plains. The Sierra Nevada, also, present a magnificent spectacle from this place. The chain appears to reach a great altitude, and to rise abruptly from the surrounding subordinate ridges. It is probable that the condition of the atmosphere was peculiarly favorable for viewing distant objects, as the outlines of the distant chain were sharply defined, and the prominent peaks showed out boldly against the clear blue sky. Snow was resting on

the summits in broad, white fields that glistened under the rays of an unclouded sun, and by its rapid melting kept the rivers well supplied with water.

The crest of the chain, nearly east from the ferry, has a very peculiar appearance, and seems to be divided into a succession of tranverse ridges, standing sharply out at right angles to the general direction of the chain, giving it an outline like the teeth of a saw.

CREST OF THE SIERRA NEVADA, FROM KING'S RIVER.

Three principal ridges of this character were easily seen by the naked eye, but with a glass many more were observed. They were evidently the outcropping edges of rocks dipping towards the south at angles of seventy to eighty degrees. Their outlines were deeply serrated; and this appeared to be the result of the breaking or gapping out of their sharp edges, either by abrasion, or, more probably, by the undermining action of the weather, permitting portions of the rocks to fall by their own weight. The nearly level spaces between these singular ridges were covered with snow, but no snow could be observed on the abrupt and precipitous slopes of the rocks. It is possible that the valleys are occupied by glaciers.

The distinctness with which these serrated rocks are visible at the distance of probably over fifty miles, and at an elevation of over seven or eight thousand feet, shows that they have a great elevation above the general surface of the ridge. A similar structure is developed along the crest of the chain for several miles towards the south. I was surprised to find such an extended series of outcrops with their trend apparently at right angles to the general direction of the chain on which they occur. From the character of their edges and the tabular appearance of their surfaces, I concluded that they were slate rocks—probably metamorphic or azoic.

From King's river to the Four Creeks the surface of the ground shows but few undulations, and may be considered as nearly level. The soil contains a large portion of clay, and must necessarily become soft and miry during the rainy season. About three miles northward of Elbow creek, (one of the "Four Creeks,") a large area of surface is composed almost wholly of clay, without any admixture of sand or gravel, and has evidently been nearly fluid in the wet season. This was shown by the deep tracks of animals in the then hard, sun-baked surface, and by great numbers of skeletons of cattle that have sunk in the deep, thick mud, and been left to die of starvation. Their whitened bones stand upright in the clay like posts around a grave. The drying up of this clayey ground has produced deep shrinkage cracks and fissures, similar to those observed in the rich soils around the bay of San Francisco.

Four Creeks.—From the level of the arid and treeless plain, bounded on the west in the dim distance by equally barren mountains, we made a sudden descent of about ten feet to the bot-

SIERRA NEVADA FROM THE [illegible] CREEK.

tom-land of the Four Creeks. Here the aspect of the landscape is suddenly changed. Instead of the brown, parched surface of gravel to which the eye is accustomed on the surrounding plains, we find the ground hidden from view by a luxuriant growth of grass, and the air fragrant with the perfume of flowers. The sound of flowing brooks, and the notes of the wild birds, greet the ear in strange contrast with the rattling produced by the hot wind as it sweeps over the dried weeds and gravel of the plain. The whole scene is overshadowed by groves of majestic oaks, and the eye can wander down long avenues of trees until lost in the shadows of their foliage.

This scene of luxuriant beauty is the result of natural irrigation, the ground being abundantly watered by the Pi-pi-yuna river, which supplies the water that forms the Four Creeks. This stream, on emerging from the foot-hills of the Sierra, divides into several channels, to which the name Four Creeks is given. These divisions of the stream diverge, and ramify over the plain, and at length empty into the Tulare lake by a number of mouths. In fact, a broad delta is here formed between the Tulare lake and the mountains, and the profuse vegetation may not only be referred to the presence of water, but to the fertility of the soil, which is alluvial, and is frequently enriched by overflows of the creeks. A fresh portion of granite debris, in fine particles, is brought down by these streams from the adjoining granite ridges, and at each overflow is spread out over the surface. The beds of the streams are generally sandy ; and the soil near them contains sufficient sand, mingled with the clay, to give it the loose, open character desirable for cultivation.

The underlying earth is doubtless a continuation of the same formation of deep clay that was observed at the crossing of King's river, and that forms the surface of much of the country between that stream and the Four Creeks.

The value and importance of this fertile, alluvial tract, as an agricultural region, cannot be lightly estimated.

The climate is undoubtedly favorable to the growth of most of the varieties of plants that are cultivated in the southern States, and the soil may be regarded as remarkably fertile. Settlements have already been made, and bridges have been constructed over some of the streams. It is probable that considerable annoyance will be experienced among settlers from chills and fever; but it might, perhaps, be avoided, to a great degree, by residing on the margin of the adjoining plains, or among the foot-hills of the mountains. A partial escape would also be thus effected from great numbers of mosquitoes that infest the low grounds among the trees.

This beautiful plain, covered with luxuriant vegetation, is a fine example of the effect of irrigation, for without these streams it would be a desert. Many of the most desolate and desert-like plains that skirt the foot-hills of the Sierra can boast a soil of equal excellence, and, if supplied with water and brought under cultivation, would reward the toil of the agriculturist with rich returns.

Lost Mountains.—Near the point where we passed from the plain to the bottom-land of the streams, one of the foot-hills of the Sierra was entirely detached from the main ridges, and stood isolated in the plain. It well deserves the title of "Lost Mountain," which is applied by the hunters and travellers of that region and the Great Basin to all similar isolated hills.

I examined the rocks of this ridge, and found that it was composed of alternating beds or seams of talcose and steatitic slates, with opaque white quartz. The quartz has an earthy luster, is full of cavities, and is in stalactitic forms, with surfaces resembling chalcedony. These siliceous seams were very numerous, and varied in thickness from one-eighth of an inch to ten

inches. In an adjoining mountain this peculiar mineral aggregation of quartz and slates is intercalated with great beds of quartz rock; in one place 100 feet in width. This has a conspicuous cleavage resembling stratification, parallel with the bedding of the slates that adjoin it. The quartz rock is granular, of a gray color, and very tough and compact. The outcrops of these rocks are considerably obscured by soil, but were sufficient to lead me to conclude that there were several parallel beds. They are inclined towards the north, at an angle of 45 degrees, and their trend is nearly east and west. They are undoubtedly metamorphic.

From the summit of this hill there is a magnificent view of the plains of the San Joaquin and Tulares, and of the oak groves of the Four Creeks, spreading out into a wide forest, and uniting on the verge of the horizon with the dark-green vegetation of the Tulares. On the other side the towering summits of the Sierra, white with snow, rise above the purple haze that rests languidly on their slopes, and project their bold outlines on the clear depths of the blue air. These elevated peaks were estimated to be 9,000 or 10,000 feet in height, and their influence upon the climate of the valley is very evident. At night, the cold air from these elevations pours down along the ravines and water-courses, seeming to flow in these channels almost like the water. It was a general observation in the camp, during our journeying along the base of the mountains, that the direction of the wind at night was uniformly *down* the cañon, while during the day it was generally the reverse.

Four Creeks to Moore's Creek, 26 *miles.*—On rising from the bottom-land of the Four Creeks, on the south side, the surface and soil of the plain is a sandy and gravelly loam, which would be exceedingly fertile, if well watered.

Near Tule river the lower ridges of the mountains on the left are composed of talcose and chloritic slates, with masses or beds of magnesian minerals, resembling ordinary serpentine. Some of the outcrops have a striking resemblance to trappean rocks. But the series was remarkable for the occurrence of some extraordinary beds of perfectly white and amorphous carbonate of magnesia, resembling opaque or massive gypsum, or plaster casts, but of finer grain and more dense. The outcrops vary from one to six feet in thickness, and stand out above the general surface of the ridge. Their snowy-white color and elevated position made them conspicuous objects at the distance of several miles. The peculiarly compact and homogeneous character of this mineral, its purity and quantity, and the absence of all traces of crystallization or cleavage, and its complete opacity, are worthy of particular notice. It is, in all probability, the most remarkable known deposit of the mineral. The action of the weather on these masses of rock has produced some singular effects. The surfaces are furrowed and grooved in every direction with miniature, crooked channels, that seem to have served to carry off the surface water. These channels give rise to small ridges, that unite in elevated points, and may be imagined to represent, in miniature, the mountains and ravines of the surface of a country. These magnesian beds, with the associate serpentine rocks, have the general strike or trend of northwest and southeast.[1]

Moore's Creek to White Creek, 26 *miles.*—Slates and serpentine, similar to those just described, were again seen after crossing Moore's creek. As these rock formations, and others that were observed in the vicinity, had characters indicative of the presence of gold, I prospected the surface gravel from the bed of the stream, but without success. I am, however, of the opinion that gold exists in that vicinity, and in the foot-hills near the Four Creeks. Cottonwood trees

[1] A full description of the mineral will be found in chapter XX.

abound on the banks of Moore's creek, and very little oak timber was seen. The river bed is shallow and sandy, and it was evident that the stream is sometimes greatly increased in volume.

On the banks of a dry creek, six and a half miles south of Moore's creek, there is an outcrop of a brownish magnesian rock, trending northwest and southeast, filled with seams and veins of translucent quartz, resembling chalcedony. It is probably a formation similar to that occurring northward of Four Creeks, already mentioned.

A short distance beyond this exposure of rock, the hills on the left appear to be formed of trappean rocks, and at the crossing of a small creek I found an outcrop of compact trap rock,

OUTLIERS OF GRANITE, NEAR WHITE CREEK.

of a dark-green color and fine grain. The weathered surfaces were clear and smooth. The apparent trend of this intrusive rock was north 30° west, magnetic.

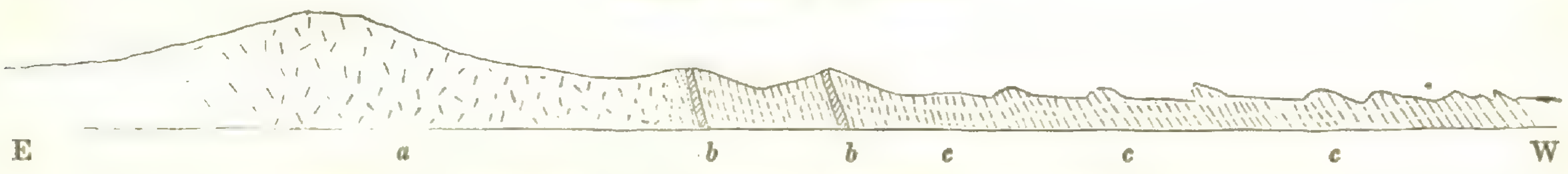
After passing Tule creek, we left the plain, and travelled among the low foot-hills of the Sierra. Two or three miles north of White creek, we came upon the edge of the granite formation, and the rock makes its appearance on the surface in a succession of long and narrow outcrops, from twenty-five to fifty feet in width, standing like walls on the gently undulating ground. They were of sienitic granite, but were undergoing rapid decomposition, weathering into rounded masses. The trend of the principal outcrop was N. 60° E., (very distinct,) dip N. 50°–75°.

Not half a mile beyond this place, the direction of trend changes suddenly to N. 20° W., (nearly at right angles with the former,) and the dip is eastward. The rock rises above the surface in similar lines, but forms a higher ridge on the left; the summit of which I found to consist of an intruded igneous rock, of compact structure and light color, breaking or cleaving up with great facility into large or small rhomboidal blocks, showing the mass to be in a con-

dition of rude crystallization. A second dike, of similar lithological character, with a trend N. 30° W., was found on the summit of an adjoining ridge. Neither of these intrusive dikes of trappean rock were over fifty feet in width. They apparently conformed in dip to that of the granite, which was not far from vertical.

The relations of these rocks, and the peculiar form of the outcropping surface, will be understood by the inspection of the annexed sectional representation:

SECTION NEAR WHITE CREEK.



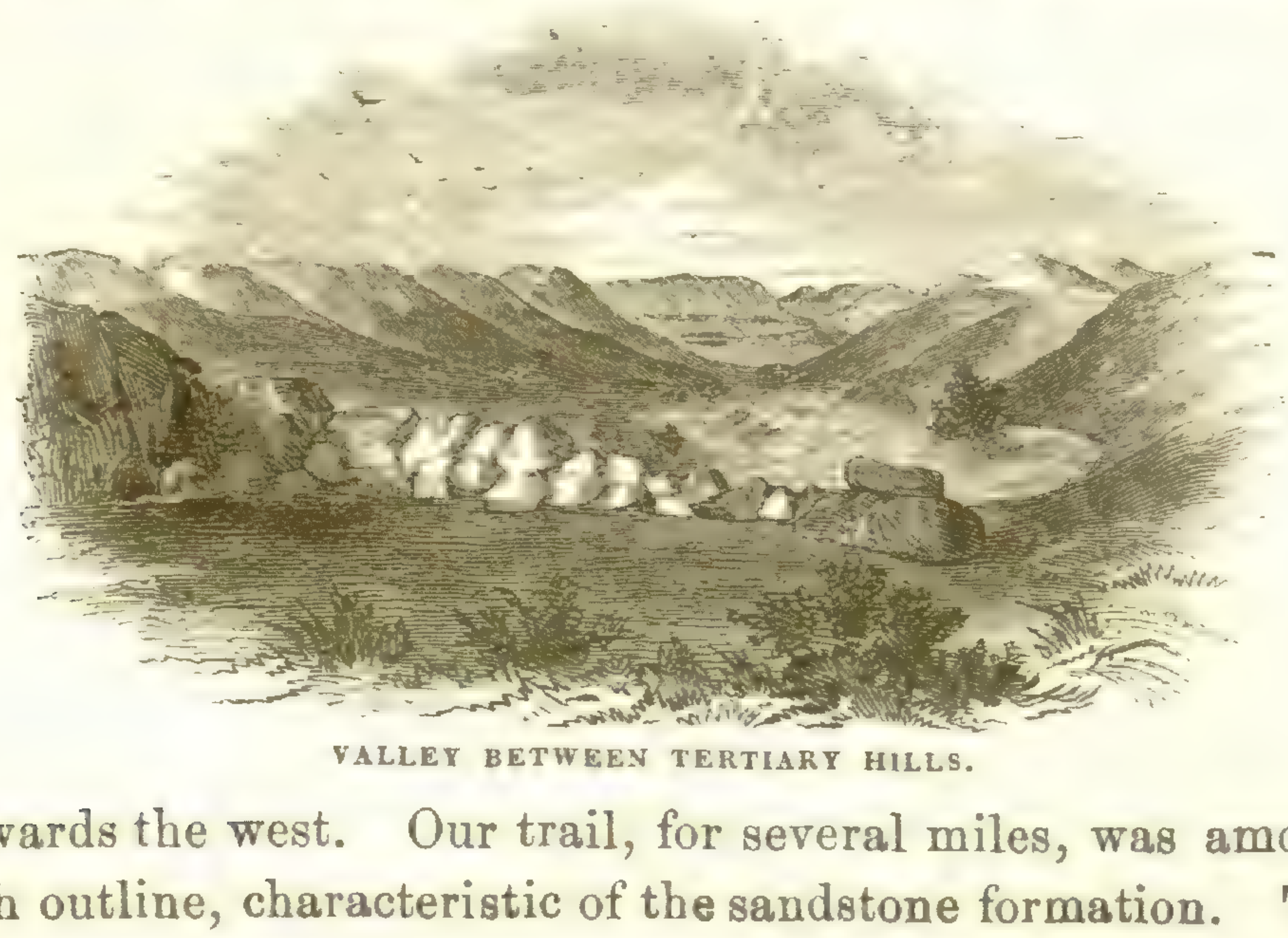
a, granite; *b b*, trapdikes; *c c c*, granitic, laminated, and probably metamorphic.

From the appearance of the ridges for several miles to the eastward, and the character of the outlying rocks, I concluded them to be a continuation of this granite series.

Before reaching "White creek," an outcrop of dark-colored, highly crystalline rock, apparently intrusive, appears on the summit of an elevated hill but a short distance from the granite outcrops that have just been described. This rock, when seen from a distance, glittered in the sunlight as if it was filled with plates of mica. These reflections proceeded from flat cleavage surfaces of broad crystals of hornblende, one-half to three-quarters of an inch in length, forming the main constituent of the rock. The outcrop of this aggregation was so limited in extent that no observations upon the trend, or the associated rocks, could be satisfactorily made.

On the top of the same hill, and west of the hornblendic rock, there are obscure outcrops of ferruginous quartz, intersected and crossed by a net-work of white quartz. Many loose fragments of red and jaspery quartz were picked up on the side of this hill. The whole locality was worthy of a more extended examination than it was in my power to make.

White Creek to Ocoya, or Posé Creek, 24½ miles.—On the banks of White creek, at the place of our camp, there are two or three nearly precipitous bluffs, one hundred to one hundred and fifty feet in height, with a steep slope of debris at their base. The color of these rocks, und the traces of stratification and absence of crystalline character, disposed me to regard them as altered sandstone; but a further examination before leaving camp led me to consider them as of igneous origin. They had the appearance of stratified rocks set on edge. Stratified formations of sedimentary origin do, however, occur on the south side of the creek, and are first seen in the sides of low rounded hills bordering our trail. These beds were of argillaceous sandstone, and had a



VALLEY BETWEEN TERTIARY HILLS.

slight inclination towards the west. Our trail, for several miles, was among hills of this peculiar, rounded, smooth outline, characteristic of the sandstone formation. The subjacent granite

was evidently not far below us, as we several times crossed limited exposures of its surface rising up in the valley among the sedimentary hills.

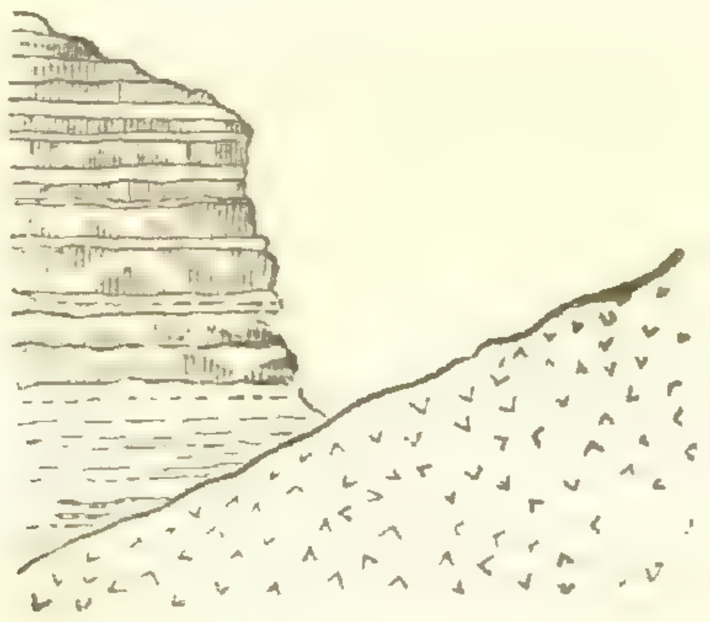
All these sediments rest immediately upon the granite, and are generally horizontal, or dipping gently westward.

The preceding sketch was taken from the top of a hill of granite at the head of a small valley bounded by the rounded hills. At its lower end the nearly horizontal strata were exposed in a series of beds of sandstone.

The streams that traverse this region have excavated deep channels in these nearly horizontal formations, producing good natural sections of the stratification.

One of these vertical exposures of the sedimentary beds consists of white argillaceous sandstone in a soft, earthy state, filled with small grains of white quartz, apparently derived from the decomposition of feldspathic granite. The mass emits an argillaceous odor when breathed upon; and some portions of the beds resemble the crude Chinese kaolin. These beds are near the underlying granite. Other exposures in the hill-sides displayed strata of similar materials, and an occasional admixture with layers of rounded pebbles. One of the outcrops presented a section in which the underlying granite was visible, as is shown in the little figure at the end of the chapter, which will also serve to give a general idea of the character of the beds of the small ravines along the borders of this tertiary, sedimentary formation, where the granite is near the surface.

Sedimentary hills, of the character previously described, bounded our trail for several miles before we reached camp on Posé, or Ocoya creek. Many of these hills are so steep that it was difficult to get the wagons of the train over them; but the absence of any vegetation, or of outcropping rocks, permitted the ascent to be made, in many cases, by winding around the slopes up the side ravines. The great number of these narrow valleys or ravines that we were obliged to cross rendered the journey exceedingly irksome and fatiguing. Occasionally in the hill-sides the edges of some of the harder strata were visible, but the degradation and wearing away of the formation has generally left a uniform coating of debris or soil, which gives a rounded contour to the hills, and covers the strata from view.



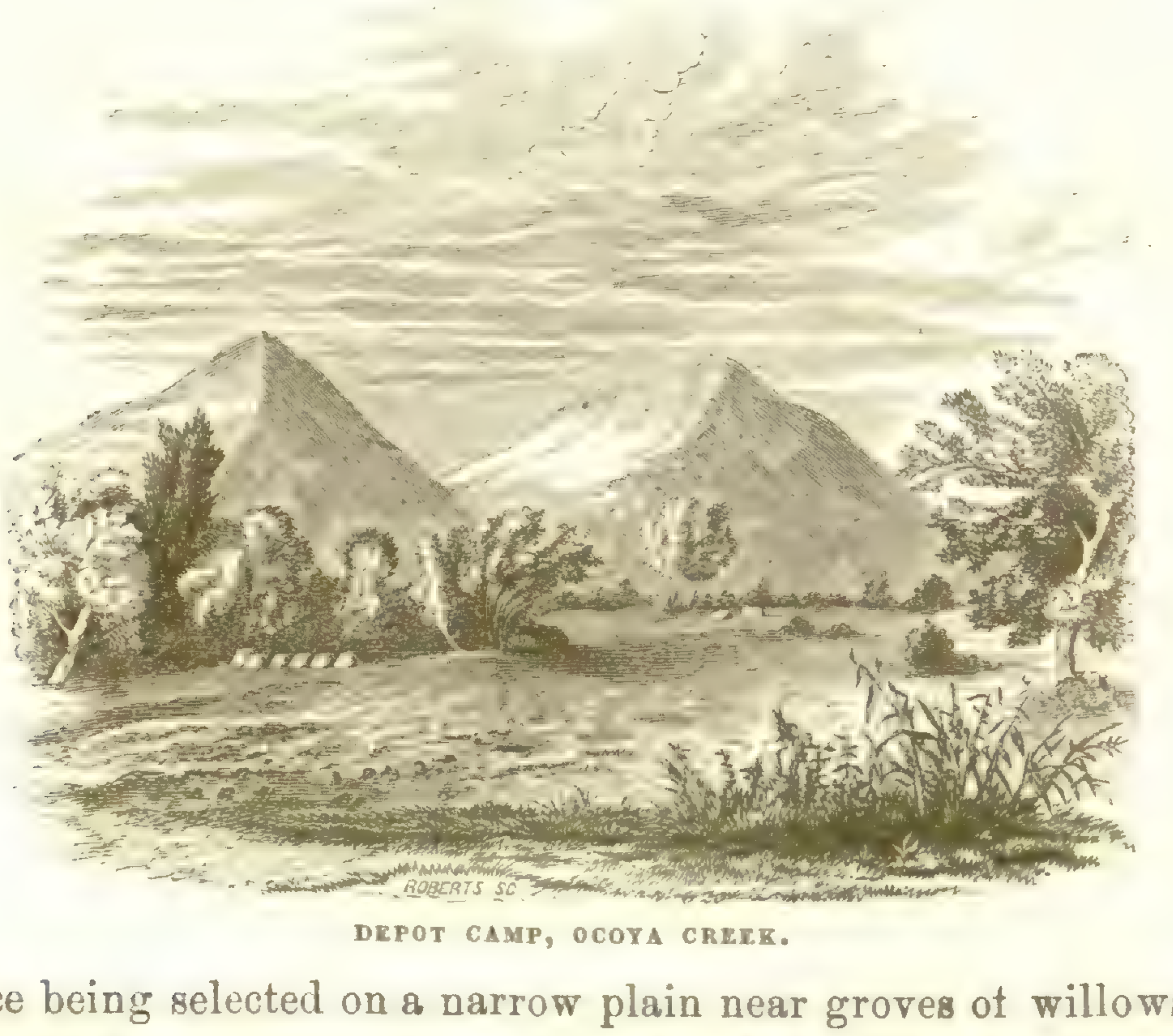
CHAPTER IV.

OCOYA CREEK DEPOT CAMP—OCOYA CREEK TO THE TEJON—TEJON DEPOT CAMP.

Ocoya creek.—Rounded hills.—Fossils.—Charcoal and pumice-stone in the strata.—Hills between camp and the posuncula river.—Bottom-land of posuncula river.—Swamp or shallow pond.—Rounded hills on the west side of the tulare valley.—Sandstone and fossils of ocoya creek.—Selenite.—Sharks' teeth on the hills.—Ocoya creek to the tejon.—Steep slopes of the hills.—Posuncula river.—Terrace.—Fossil-stems.—Conglomerate.—Terraces.—Light argillaceous soil.—Tertiary hills.—Drift at tejon creek.—Tejon.—Sierra Nevada.—Depot camp.—Soil of the tejon.—Oak openings.—Indian reservation.—Cultivation of the soil by indians.—Grapes.—Climate of the tejon valley.

We reached Ocoya, or Posé creek, on the 8th of August; it was then almost dry, and water could be found only in deep and shaded holes of its channel. The low banks and bottom-land were timbered with a dense growth of cottonwoods and willows, and considerable grass was found along its borders. The green strip of vegetation showed out in strange contrast to the barren and parched surface of the surrounding hills, which were without trees or any green vegetation.

This absence of trees permitted all the outlines to be seen, and they were all finely curved and rounded by the action of the weather. The soil upon their surfaces looks very light, and is nearly white. They appear to be composed of sand and sandy clay, regularly stratified, and alternating with strata of gravel and coarse sand. Pumice-stone, also, occurs in layers, and in some places forms a large part of the strata.



DEPOT CAMP, OCOYA CREEK.

Our camping place being selected on a narrow plain near groves of willows and cottonwoods, preparations were made for remaining two or three weeks, while a preliminary reconnaissance

was made in the mountains in the region of Walker's Pass. During the absence of this party I remained in camp, and had a fine opportunity to examine the geology of the vicinity.[1]

August 9.—Found a thick bed of the relics of shells in one of the hills on the left bank of the creek. They are marine fossils and the lime has nearly all been removed, but perfect casts remain in the sand and clay, it being firmly cemented by peroxide of iron. Collected numerous specimens.

August 10 *and* 11.—Engaged upon the locality of fossils and procured fine specimens. In another stratum, higher up in the series, found masses of *charcoal* imbedded with pumice and fine sand, also an impression looking like a part of a leaf.

Our hunters brought in several fine deer and antelope and a small grizzly bear.

August 12.—Started with Captain Stoneman, Dr. Heerman and Mr. Koppel to go to Kern Lake, or the western side of the Tulare valley. We passed down Posé creek for about one mile, and then turned to the south over the hills dividing the waters of the creek from those of Kern or Posuncula river. These hills, like those at the camp, were composed of argillaceous sandstone, and I estimated them to be from five hundred to nine hundred feet high. We followed an Indian trail over some of the highest of them. They appear more argillaceous at the top than at the base, and are much cut and worn away by water, forming very steep slopes. In some places there are great slides of the earth, and vertical cliffs of clay and sand are formed nearly two hundred feet high. We reached Posuncula river and passed down its right bank on the margin of a slough or bottom-land. Our progress was finally stopped by the thick growth of canes, rushes and willows. We retraced our steps and kept on the outside or margin of the bottom-land, travelling on the dry and barren plain by an Indian trail. This led to several deserted rancherias and play grounds. About eight miles below the point where we first struck the stream, the bank of the slough was nearly twenty feet high, and formed a terrace of that elevation nearly a mile long, and then sloped down to the general level the of plain. A mile and a half beyond, it was again found at about the same elevation and extended three or four miles, when it again sloped off and was not found afterwards. This portion of the river bottom was without timber; but the moist land was indicated by a thick growth of grasses of various kinds, many of which were collected. Several Indians were seen carrying baskets on their backs, and we soon found that they were collecting grass seed, heaps of it being seen. This is, probably, a part of their winter food.

We travelled until after sunset, and not being able to find any water encamped without it upon the plain. There was no dew at night. It was almost impossible to sleep, there being myriads of mosquitoes.

August 13.—The thermometer at sunrise indicated a temperature of 58°. We rose early and pressed forward towards the hills of the Coast Mountains, which now appeared very near. After riding about fifteen miles, we reached the margin of a swamp or low ground, without any vegetation except tufts of coarse grass and the common "grease bush." The clay, however, was soft and charged with water, which stood about one inch deep in the shallows. Beyond, and between us and the lower hills of the Coast Mountains, a sheet of water was found to extend. It did not appear to be more than half a mile broad, and yet it was, in all probability, two miles to the hills. These hills were barren and rounded similarly to those of Ocoya creek, which they so closely resemble that I have little doubt of their identity in lithological character and age. After scooping up enough of the warm, muddy water to make coffee, we

[1] A special description of the geology of this region will be found in Chapter XIII.

returned towards the mouth of Ocoya creek, and arrived in the evening, having had a hard ride of about fifty miles. In numerous places over the plain there are dry water courses or canals in the clay, and groves of dead cotton-wood trees. It is probable that the whole region has been subject to overflow. It should be observed that the water of the slough, or lake, was more or less saline, incrustations being found around the roots of the tufts of grass, where evaporation had proceeded rapidly. Specimens of scoriaceous cinder, or volcanic slag, were also found lying on the clay surface of the plain.

August 14, *Sunday.*—The thermometer indicated a temperature of 102° in the shade during the middle of the day; and a hot dry wind was constantly blowing from the west, following the course of the valley of the creek.

August 15.—Examined the strata up the creek and on the right bank. The hills are in all respects similar to those on the left. At one point, however, an outcrop of coarse-grained sandstone and conglomerate was found; it was harder than the other strata, and modifies the outline of the hills. At sunset clouds were seen over the mountains at the east. The day was unusually warm, the thermometer standing at 104°.

August 16.—Collected more fossils, and made drawings of them; they are evidently Tertiary, and probably quite recent—Miocene or Pliocene. Fresh water shells are abundant in the pools of the creek, and specimens were preserved.

August 17 *and* 18.—Obtained the order of succession and lithological characters of the strata forming one of the highest hills on the left bank of the creek. The edges are fully exposed in several places, and in others are partly obscured by soil.[1] Just before sunset we had a short shower, and the clouds looked very heavy over the mountains.

August 19.—Made more extended excavations in the bed of fossils, and procured five or six additional species. Most of the specimens became broken and mutilated in taking them out. Some very large pectens were found, six inches in diameter; one of these was drawn by Mr. Koppel. While he was turning over one of the masses of sandstone he was stung by a scorpion, carrying a great number of little ones on her back. The application of a little ammonia water quickly relieved the pain, and no further inconvenience was experienced.

August 20.—Found an additional number of species, and among them a shark's tooth. Specimens of transparent selenite were obtained from the tops of some of the hills and from the bed of the creek. The water in the deep holes has now become very low, and is strongly impregnated with sulphur. It has the odor of sulphuretted hydrogen. Thermometer 103° in the shade. A comet was visible in the west this evening.

August 21.—The night was cold, and at sunrise the thermometer stood at 56 degrees. The wind was blowing from the northeast, or down from the mountains, and this is generally the case early in the morning.

August 27.—I have been prevented by illness from making any geological observations for several days. The sudden and great transitions from a temperature of 103° and 104° during the day to 40° and 50° at night, together with the use of stagnant water, are sufficient to produce disease. On the evening of the 25th, I set up a pan of water in the shade of the brush-shed, in order to determine, if possible, the rate of the evaporation of water during the day. The hunters came in from the plains, bringing six fine carcases of deer and antelope, one of them a fat buck, weighing, when skinned, 115 pounds, and his hind-quarters over 60. It was of the black-tailed species.

[1] This section is described in Chapter XIII.

August 28.—We were visited by several Indians from Posuncula river. They brought a fish, weighing about three pounds, and dressed deer skins for sale.

August 29 *and* 31.—Examined the lithological character of several of the hills about camp, and obtained sections. On the tops of two of the hills opposite camp a great number of shark's teeth of different sizes were found lying loose on the surface, having been washed out by the rains. Fragments of bone and of fossil wood were also procured. The elevation of these hills above camp is about 500 feet, according to the aneroid barometer.

OCOYA CREEK TO THE TEJON.

Ocoya Creek to Posuncula River, September 1—10.8 *miles.*—The road or trail connecting Ocoya creek with Posuncula river winds about among the rounded Tertiary hills already described, and a fine view of the almost innumerable ravines and gulches that furrow their sides is presented. The remarkable steepness of the slopes is also very distinctly seen along this trail, the inclination often becoming 35°, so steep that it was impossible to ascend without first cutting a foothold. Several land slides were also observed, where great hills appeared to be cut down through the centre, exposing all the lines of stratification on the face of a vertical bluff. These slides probably take place in the rainy season, when the soft clay and porous strata become soaked with water, so that their weight is very much increased. The material which thus breaks away from the hills is in a condition to be rapidly acted on by running water, and is quickly removed to the lower grounds. The trail for the greater part of the distance between the two streams follows the bottom of one of the ravines or water courses; it is, of course, very tortuous, and in some places is so narrow that the wagons were forced to travel partly upon the slopes of the hills. A sketch by Mr. Koppel presents a good view of the hills along a part of this ravine, and serves to give a good idea of the general character of the hills near our camp on Ocoya creek. (See View X, Chapter XIII.) Posuncula, or Kern river, like Ocoya creek, has a nearly westerly course for a short distance after leaving the granite ridges of the Sierra. It also traverses the belt of Tertiary foot-hills, and makes good natural sections of the strata along

VALLEY OF POSUNCULA RIVER.

its banks. The section it forms on its southern or left bank presents an interesting appearance when viewed from the tops of the hills, at the divide between its waters and those of Ocoya creek. The bank is seen to extend many miles, with a nearly uniform elevation above the stream, presenting an even outline like the edge of a table land or terrace. It is, in fact, the

margin of a table land or gentle slope, that inclines slightly towards the south, and becomes merged in the slope of the Tulare valley. It is a portion of the former plateau of Tertiary strata, but is much lower than the other portions undoubtedly were, and it may, therefore, be concluded that the former sedimentary plain sloped gradually off in this direction, thinning down to the level of the Tulares.

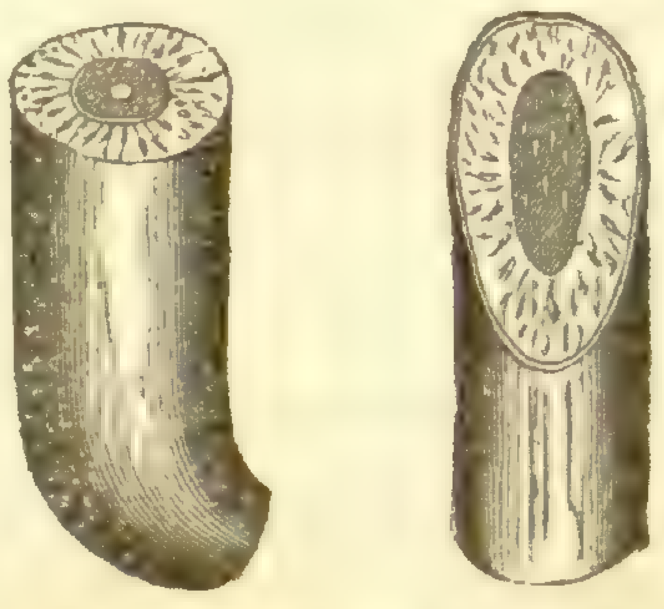
A view of this long even bank is given in the sketch. The round Tertiary hills are seen in the foreground, and Posuncula river, with its broad delta, occupies the centre of the scene. The broad belt of timber is on the sloughs of the river bottom, where it spreads out near the southern lakes of the Tulares. The western border of this belt of Tertiary formation, from Posé creek southward to Posuncula river, slopes off to the west, and passes insensibly into the Tulare plains by a succession of gradual and gentle undulations of the surface.

It appears that the sand and gravel that has been brought down from these Tertiary hills by alluvial action has been deposited along at their base; while the clays and finer volcanic sands have been carried further out into the Tulares. In this way a narrow margin of nearly level surface, composed of gravel and sand, has been formed at the base of the sedimentary hills, separating them from the soft and clayey soil of the Tulares. This narrow belt affords a good foundation for the construction of a railroad.

Posuncula, or Kern River, to the Tejon Pass, September 2—31.13 *miles.*—The hills and remnants of the elevated plateau adjoining Posuncula river exhibit, in many places, accumulations of cobble-stones and small boulders much above the present level of the stream. They are, doubtless, the remains of the drift of a former bed of the river, when it flowed at a higher level than now, as they do not appear to have been derived from the subjacent strata.

Posuncula river, at the ford, is a deep, rapidly flowing stream; and its banks are lined with great accumulations of drift rocks, in masses much rounded by transportation in water. These consisted principally of syenites and basaltic and flinty rocks, varying in size from six inches to two feet in diameter.

Fossil stems.—Among these boulders I found a mass of a jaspery, silicious rock, of a yellowish color, that was filled with silicified fossil stems, preserved so completely that every cell and tube was distinctly visible. Some of the fragments are represented of the natural size in the annexed figures. The oblique section of the stem was drawn so as to show the arrangement of the cells and radiating lines.



FOSSIL STEMS OF PLANTS.

The boulder containing these beautiful stems was about eighteen inches in diameter, and is a short distance below the ford, on the right bank of the stream. It must have been transported from the headwaters of the river, or from the sedimentary beds a short distance above, having been broken out by the action of floods. It is very desirable that the original locality of these fossils should be discovered, and their geological associations made known. It is probable that the examination of the rock in situ would develop many interesting forms not found in

these transported fragments. Similar fossils were afterwards found, in place, near the summit of the Sierra Nevada, at the pass called the Cañada de las Uvas.—(See chap. V[1].)

Posuncula, or Kern river is one of the most important streams that enters the Tulare valley. It is the most southern of the tributaries to the Tulare lakes, and enters that now called Kern lake by a number of mouths. After the river emerges from the Tertiary hills, it turns abruptly from its westerly course to the southward, and spreads out over the slope by a number of shallow channels, which thus form a broad bottom land covered with timber and grass.

It was evident that this river is liable to great floods, and that the current is at such times very rapid and powerful. The low bottom lands or banks were not very broad, but were thickly overgrown with cottonwood, sycamore, and willows of several kinds.

The water of the river was perfectly clear, and at the ford the temperature was 67° ; but it must become more and more elevated as the water descends to lower parts of the stream in the plain, where it spreads out into the many sloughs, that are comparatively shallow, and expose large surfaces to the rays of the sun. A conglomerate of sand and gravel is exposed in the bed of the river, which resists the wear of the current exceedingly well.

Terraces.—Indistinct terraces were observed on the southern bank ; and the upper one forms the long, even outline, before referred to. From the top of this terrace the road descends gradually toward the south until the Tulare plain is reached. The soil for the greater part of the distance contains a large proportion of clay, and is exceedingly fine. When broken up by the animals, it became perfectly light and dusty, and resembled dry ashes. This argillaceous and light character is principally confined to the lower parts of the slope and to the plain. The soil probably is not good or so well fitted for cultivation as the purely granitic soils found in the vicinity of the granitic and metamorphic rocks where the Tertiary strata are absent.

We soon reached the foot of the slope ; or it became so gentle that we appeared to be traversing a wide plain. On the west the view towards the Tulare lakes was unobstructed, and on the east the mountains were formed of several ridges. High peaks were seen, but they were without snow.

The high ridge, or mountain, along the western base of which we travelled, appeared to be well timbered to its top, and no outcrops of rock were visible. We were, however, several miles distant, and the rocks may have been hid by the trees. This ridge, as it extends to the south, decreases in altitude, and finally passes below the general level of the plain or mountain-slopes. Our course was directed to this point ; and on turning it, a broad area, several miles in width, and nearly level, was brought to view. It extends back from the ridge, eastward to the main chain of the mountains, and is enclosed on three sides, being a broad valley, or partly enclosed slope, called the *Tejon.* It is traversed by a creek issuing from a pass in the mountains, and this creek cuts through the southern point of the low ridge which separates the valley from the Tulare plains.

The low, rounded hills of the Tertiary formation appear to skirt the Sierra Nevada southward from the cañon of Posuncula river to the extremity of this low ridge. At this extremity they are developed in a narrow belt of elevations, which in many places present vertical exposures that are white and chalk-like. They are probably a compound of white volcanic sands and ashes, and the debris of white granite. Near the entrance to the valley of the Tejon creek I found large accumulations of drift confusedly stratified, and obscuring the stratification and lithological characters of the Tertiary strata. This drift is principally of syenite and coarsely crystallized granitic

[1] See also a description and drawing by Professor J. W. Bailey, Appendix, Article V.

and metamorphic masses, some of them a yard in diameter, and confusedly intermingled with smaller masses and coarse gravel. It also contains pebbles of porphyry, and other volcanic rocks. This is a portion of a continuous series of drift accumulations and erratics that are found along the slope flanking the Sierra in this region, and they bear evidence of having been transported by a powerful current from the mountains.

TEJON.

In ascending the slope of the Tejon several Indian rancherias were passed. The ground about them appeared to have been rudely cultivated, irrigation being resorted to. Other portions of the plain were dry and gravelly. Further up the slope, however, and along the creek, fine groves of oak trees were found and an abundance of excellent grass. We crossed the creek and encamped in a beautiful grove, not far from the camp of Messrs. Ridley and Brooks, who have made some improvements and cultivated a number of acres.

TEJON DEPOT CAMP.

Mountains are visible from our camp on all sides, but those on the southwest are distant and are on the western side of the southern end of the Tulare plain. They are the southern portion of the Coast Mountains, and appear to curve around so as to unite with the southern end of the Sierra Nevada. The mountains on the east of camp—the Sierra Nevada, if they may be so called—are without snow at this season, and are much lower than the portion of the chain further north. The first ridge of the chain may be said to be on the west of us, the same we crossed when travelling from Posuncula river; but the principal ridge is in full view on the east, and is about three miles distant. Its surface is brownish yellow, and is partly shaded by oak trees standing apart, at wide intervals.

A creek (Tejon creek) issues from the pass and flows down over the broad plain or slope of the Tejon. For the first part of its course it flows near the mountains on the southeast side, but then turns and flows across to the northern portion of the valley. Its course is marked by a line of trees and shrubbery, while the surrounding surface is perfectly bare and desert-like.

The point selected for the depot camp was on the border of the creek, about three miles from the entrance to the pass, being in the northern or northeast part of the Tejon, as represented on the general map.

The surface of the Tejon slopes gently away from the surrounding mountains, but the descent is so gradual that it appears almost level.

Soil of the Tejon.—During the summer season the slopes of the Tejon generally present a uniform brown or drab color, similar to that of the San Joaquin plains. They look barren and desert-like, and the soil seems to be merely ordinary gravel and sand and not suited to vegetation. On examination, we find that this granular gravel is the debris of granitic rocks, and that it contains a large amount of feldspar and mica. It is not rounded and water-worn, but is angular and friable, being chiefly fragments of granite which are rapidly decomposing and form a loose but rich soil, capable of supporting a heavy growth of vegetation and well adapted to agriculture.

This soil, although rich in all the important inorganic constituents, is almost without the common vegetable mould that gives the dark color to soils that have long been subjected to cultivation.

This absence of humus is a prominent characteristic of the upland soils of California, and is caused by the prolonged drought of the dry season, which destroys the vitality of the roots of grasses and other plants, and thus prevents the formation of a sod.

The portion of the valley in the vicinity of the camp was well timbered, being covered by groves of beautiful trees.

Nearly all of the trees were oak, the same species as those seen in the valleys near Martinez and Livermore's. It is the *Quercus macradenia* of Dr. Torrey, or *Q. Hindsii* of Bentham.

These thick groves of wood and the luxuriant growth of grass, whenever the ground was sufficiently shaded and moist, show the depth and the agricultural capabilities of the soil.

The cultivation around the Indian rancherias, located in different parts of the valley, also exhibited the fertility of the soil. The ground about many of them was well cultivated, water being brought from the creek by numerous acequias to irrigate the surface. In these fields, corn, barley, and melons were growing luxuriantly, and it was evident that the ground only required water to make it productive.[1]

It is probable that grapes could be cultivated in this valley with success. The borders of the creek were overgrown in places by thick masses of grapevines, loaded with long and heavy clusters of fruit. This grape is deserving of attention, as it is probable that it will be found an exceedingly valuable variety for the manufacture of wine. The berry is small and round, and much resembles the ordinary "frost grape" of New England; but it is larger, more juicy and rich in flavor, and also has a high color, yielding a juice of a rich claret-color.

[1] While we were at the Tejon, Lieutenant E. F. Beale arrived from the Atlantic States, having been appointed Superintendent of Indian affairs for California. The Tejon was selected by him as the most appropriate place for an Indian Reservation, and he collected together a great number of Indians, provided them with agricultural implements, and induced them to cultivate the soil. A canal, five feet wide and three deep and ten miles in length, was constructed for purposes of irrigation. Nineteen hundred (1,900) acres in one field were sown with wheat, and seven hundred Indians were at work upon it at one time. Forty, and sometimes fifty, ploughs were employed on this field, and it was found that the ground broke readily, being free from roots and rocks or other obstructions.

Climate of the Tejon Valley.—We reached the Tejon on the third of September, and portions of the Expedition remained there until the ninth of October. At the time of breaking up the camp the temperature during the days was from 80° to 90°, and at night about 60°. The weather was evidently becoming cooler, and we were forcibly reminded of the approach of winter by the flocks of wild geese that passed to the southward every night. The Indians were engaged in collecting the thick clusters of ripe grapes for their winter use, and all the crops of melons were harvested. I learned from Mr. Ridley, one of the two settlers of this place, that the winter rains commence about the 15th of December, and that then the grass springs up rapidly, and is green through the winter; by the month of April it is high on the plains, and is preferred by the cattle to the grass on the bottom land of the creek. The autumn months of October and November are the only ones without an abundance of green grass; and this period may be regarded as the winter for cattle. It is said that snow sometimes covers the Tejon slope for a short time during the winter. Lieutenant Beale, who remained there during the rainy season of 1853–'54, informs me that the ground was thinly covered from the base of the mountains nearly to the lakes, and that ice was once found half an inch thick. This was considered as remarkable, and as an unusually severe winter. Snow, also, accumulated in the ravine of the pass to a depth of several feet, and it is, undoubtedly, found there in considerable quantity almost every winter, and also on the elevated valley of Tah-ee-chay-pah.

During the stay of the main party and the escort at the Tejon, a full geological examination of the pass was made in connexion with Lieutenant Williamson's surveys. The Cañada de las Uvas was also examined, and an expedition made to the vicinity of the pass of San Amedio at the head of the Tulare valley.

Other fields were planted with barley, corn, and vegetables, and the different Indian villages were surrounded with smaller fields similarly planted. The following tabular statement will give an idea of the extent of the crops raised, of the fertility of the soil, and the adaptation of both the soil and climate to agriculture:

Description of crop.	Amount in bushels.	Number of acres.	Bushels per acre.
Wheat	61,530	2,051	30
Barley	8,000	400	20
Corn	12,480	416	30
Beans	500	25	30
Turnips		10	
Pumpkins, melons, and cabbages		300	

The crop of one acre, that presented a favorable appearance, was carefully measured, and the yield found to be *fifty bushels.*

A nursery of young fruit trees was commenced and planted with upwards of two thousand plants, including grapevines, pear, orange, fig, pomegranate, peach, apple, and cherry trees. These all appear to thrive well, and will, doubtless, develop rapidly.

The Indians, by whose labors these results have been accomplished, came from remote portions of California, and speak different languages.

Mr. Beale appears to have been remarkably successful in his attempt to control these savages, and to cause them to labor for their maintenance. By judicious management, they have been led to labor together cheerfully, and to become greatly interested in their occupations.

When I was last at the Tejon, in October, 1853, the ground on which these crops were raised had never been furrowed by a plough, and in the summer of 1854 the crops mentioned in the preceding table were harvested. No better evidence of the fertility of soils, composed of granitic gravel and sand, can be presented.

CHAPTER V.

TEJON TO SAN AMÉDIO—CAÑADA DE LAS UVAS.

Reported existence of silver.—Entrance to the Cañada de las Uvas.—Sandstone strata probably tertiary.—Miocene fossils.—Contorted strata.—Upraised sandstone strata.—Oak trees and acorns.—Mountain sheep.—Granite and gneiss.—Ruins of a forge.—Sulphuret of antimony.—Fir trees.—Granite of the ravine.—Large masses of antimony ore.—Outcrop of the vein.—Gossan.—Gypsum.—Altitude of the vein.—View from the top of the mountain.—Coast mountains.—Dry lake or basin.—Return to the Cañada de las Uvas.—Section of sandstone strata.—Mountain sheep.—Deer.—Cañada de las Uvas.—Drift from the pass in the creek.—Sandstone filled with fossil shells.—Granite and metamorphic rocks.—Oak trees.—Grizzly bears.—Open valley.—Limestone.—Dry lake covered with salt.—Grizzly bear.—Granite and erupted rock.—Upraised strata of sandstone.—Rounded hills.—Erupted rock in dykes.—Section of sandstone strata.—Fossil stems of plants, silicified.—Ridges of white limestone at the summit of the pass.—Iron ore.—Tertiary strata.

During our stay at the Tejon, I learned that masses of ore were found in the mountains to the southwest, about twenty miles distant. It was supposed to be lead or silver ore, being called "*plata*" by the Indians, who seemed to think it could be found in immense quantities. After the completion of the geological examination of the Tejon, it was arranged that I should visit the locality to determine, as far as possible, the nature and value of this mineral.

September 20.—Through the assistance of Mr. Ridley, who was living in camp in the valley at the time of our visit, the services of an Indian guide, named José, were procured, and I started, with two men, for the locality. We passed southward, across the slope of the Tejon, towards the mountains at the head of the Tulares, intending to pass by the entrance to the Cañada de las Uvas—a long and favorable pass through the mountains to the Great Basin. We passed, on our way, the cultivated fields of several Indian villages and an adobe house, built by an American, but now occupied by Indians. The path from this point leads over gently undulating ground and some low, rounded hills, to the level of the Tulare plain; and after this is traversed for a short distance, the ascent of a long and gentle slope to the mountains is commenced. At the upper part of the slope and at the base of the mountains we found one or two Indian huts, occupied by Antonio, one of the chiefs of the Tejon Indians. He received us very graciously, conversing in Spanish, and sold us a very fine watermelon, raised upon his ground. This place is at the entrance to the Cañada de las Uvas, and is about fifteen miles from the Tejon camp. The soil for nearly the whole distance was found to be hard and gravelly, and no stones larger than an egg were found until the foot of the mountains was reached. They are, however, found of considerable size along the whole course of the Tejon creek, showing the former power of floods from the mountains. At the mouth of the Cañada, where there is also a small creek, the boulders were very abundant and of considerable size. Blocks of granite and hornblendic slates and gneiss, together with masses of white crystalline limestone, were seen, and they indicate that the rocks of the Cañada are similar to those of the Tejon.

We travelled westward from this point over the upper part of the long slope from the mountains, keeping as near the foot-hills as possible. There was but little or no vegetation, and the surface was dry and gravelly. Numerous dry gullies or arroyós descend from the ridges, and

their banks are lined with debris, consisting of various volcanic and sedimentary rocks. Boulders of beautiful porphyry, filled with grass-green crystals, were found at one of these dry water-courses, and from their numbers I inferred that the rock was in place in the ridges. Other porphyritic boulders were of a delicate pink or lilac color, and some were brown and black.

Sandstone Strata, probably Tertiary.—After traversing the slope westward from the Cañada de las Uvas for about eight miles, I turned southward and followed up the course of the dry bed of a stream among the low foot-hills of sedimentary origin, which are much cut by ravines, and present a barren appearance when viewed from the Tejon. Before reaching this *cañada* I found a block of sandstone near the trail, from which casts and impressions of shells of the genera *Meretrix* and *Stramonita* were obtained. The specimens that were preserved are regarded as new species by Mr. Conrad, and he has named them *Meretrix Tularana*, Pl. III, Fig. 22; and *Stramonita petrosa*, Pl. VI, Figs. 47 and 47[a]. They are probably of Miocene age; and there is little doubt that the boulder was brought down by floods from the adjoining hills. After traversing the cañada for a short distance, it was observed that the strata in some places were much distorted, being uplifted and set nearly on edge, and so bent that the stratification showed out in curved lines along the banks, with a southerly dip. These strata were much obscured in places by a recent drift or detritus, forming a conglomerate which rested unconformably upon their edges and filled the inequalities of surface. This is a local drift, and has apparently accumulated during the excavation of the valleys, the higher beds being the oldest, having been transported and deposited before the stream had excavated the channel to its present depth.

As the cañada was ascended the hills became higher, and I soon found good natural sections of the strata with the dip towards the north.

We left this valley, where there is running water and a line of cottonwood trees, and ascended the left bank, passing again towards the west. The point at which we turned is near the line of junction of the sedimentary formations with the granite. This may be known by the greater amount of the foliage on the granitic rocks and the growth of large evergreen trees, and by the difference in altitude and outline. A high bluff of sandstone was also near. We travelled over a very rugged and irregular path, seeing high bluffs of sandstone on the right, and on the other hand, or south side, thick strata of sandstone were resting at an angle of nearly fifty degrees; the tabular masses being broken and showing finely, with oak and pine trees, and shrubs, growing in the fissures and between the overlapping strata.

The path, we followed, led us for a long distance at the foot of hills composed of these hard sandstones, and it was evident that we followed the line of trend. The surface on each side was overgrown with dwarf-oaks, so thick and strong that they were impenetrable, and we were obliged to follow the bed of the creek, now entirely dry. The oaks were loaded with acorns of various sizes and forms,[1] and these appeared to be much sought after by bears, their paths and tracks being very numerous, and the only ones that were found. A large quantity of pebbles, composed of trappean and porphyritic rocks, were seen along this creek, and may have been washed out of the surrounding beds of sandstone and conglomerate.

On reaching another deep valley, apparently extending towards the Tulares, we again turned southwards towards the high mountains, then very near us, and looking invitingly green and

[1] Leaves and fruit of the most common species were collected, and have been submitted to Dr. Torrey. It is considered as *Quercus agrifolia*; variety, *acutidens*.

well timbered. A fine section of sandstone strata was soon brought to view, the creek, or valley, being at right angles to the trend of the strata. They were much uplifted, and a very great thickness was exposed. It being nearly dark, we pressed on towards the camping place. We soon arrived at a fine spring, in the midst of a thick clump of tall reeds or canes, and encamped. The barometer, being set up, indicated an elevation of nearly 1,800 feet above the Tejon camp, or 3,200 feet above the sea.

September 21.—Left camp soon after sunrise, being detained by the absence of José, who had gone off in pursuit of mountain sheep. He soon returned, excited, but not successful. We travelled towards the high and heavily timbered ridges, and passed among a considerable quantity of sage-bush of vigorous growth. Granitic rocks were soon observed; the first outcrop was gneissose, and dips at an angle of about forty degrees northerly. This was succeeded by compact rocks retaining lines of structure, and beyond by gneissoidal rocks dipping to the southeast.

About four miles from camp we reached a spring, and near it found the ruins of a log-house. This, according to our guide, was the "*Campo de los Americanos*;" being the place where some adventurers had lived and attempted to smelt the ore. The ruins of the cabin were charred by fire; and at a short distance we found the walls or adobes of a forge or furnace, in the bed or hearth of which a mass of slag remained.

I could not find any great quantity of slag or cinder about this furnace, and concluded that it had not been used long when it was abandoned. There were no evidences of mining in the vicinity, nor any heaps of ore. José seemed to think that his duty was accomplished, and was disinclined to go further. In answer to inquiries about the ore, and where it was obtained, he only pointed to the forge and ruins, saying: "*Me sabe no mas.*" He, however, went towards the confusedly mingled debris and rounded fragments of rock at the end of a long ravine, and soon found a mass of the ore about as large as one's fist, and much rounded by attrition. On breaking this open, it was found to consist of nearly pure *sulphuret of antimony*; the freshly broken surfaces being brilliant, and like those of the ore from the East Indies. The ascent of the ravine was immediately commenced with the intention to find the vein from which the masses of ore were transported.

The view up the ravine was beautiful. The mountains rose with steep slopes to a great height on each side, and on the north, a precipitous bluff of white granite was seen above the tops of the tall firs which covered all the slopes, and grew to an enormous size in the bottom of the ravine. Some of these trees were over six feet in diameter, and probably two hundred feet high. Their foliage resembled that of the fir balsam, but the bark was not smooth nor the trunks round. Enormous festoons of gray and bright-yellow moss hung down from all the branches, and added greatly to the antiquated appearance of these noble trees.

In ascending the ravine, masses of ore were constantly found among the rocks. The great accumulation of rocks in the bottom of the ravine, piled up in long lines and thrown together in great heaps on all sides, showed that enormous floods of water descend here at certain seasons. This great accumulation of debris was at length traced to the base of an almost vertical ascent or channel on the side of a high ridge. This channel was bounded on each side by bluff walls of a light-colored granitic rock, which appeared to be exceedingly friable, and cleaved readily in various directions, as if it was completely shattered or divided by fissures. The debris of the long ravine below consisted in great part of the fragments of this rock, and the foot of the ridge was covered with it.

We commenced clambering up over this mass of broken rock, and were encouraged at every

step by finding masses of ore, some of them of great size and weight. One solid, and apparently pure mass, was found to be sixteen inches long and about ten wide; another measured twenty-seven inches long and eighteen wide. A mass of quartz was also found, traversed by long prismatic masses of the ore.

The ascent at length became very hazardous from the abrupt and precipitous character of the channel, and the quantity of loose blocks of granite which were easily dislodged and sent rolling downwards. An outcrop of yellowish-gray ochre, the "gossan" of the vein, was at length reached and seen exposed at intervals along the face of a rugged cliff. This indicated the course of the vein, which was ascertained to be about north and south. From some points of view it seemed to be west of north. The outcrop is not at the summit of the mountain, but is at one of the steepest and most inaccessible parts of its slope. It was impossible to follow the vein along its course, or to get directly below the exposure. It could be reached at one side, and several specimens of well crystallized gypsum were taken out of the gossan. The vein appeared to be from four to ten feet thick, and to be bounded on each side by granitic rock. This granite in many respects closely resembles that found in the Tejon Pass. It is traversed by lines of structure, and is very probably metamorphic. The rock adjoining the ore contained more hornblende than the rest. Small veins of carbonate of lime and some of quartz were seen traversing the rock in various directions. The altitude of this outcrop is about six thousand feet above the sea. One of Green's cistern barometers was taken up, and the height of the column found to be 24,320 inches; attached thermometer, 88°, 9 A. M.

From this point I ascended to the top of the ridge with considerable difficulty and exertion; at one time climbing a dwarfed oak tree in order to get over a vertical wall of rock. The vertical distance from the vein to the top of the mountain must be about one thousand feet, but it appeared to be much greater. I was well repaid for the labor and fatigue of the ascent by the splended view from the summit. Northwards, the vision was unobstructed, and the broad, extensive valley of the Tulares was before me. On one side the heights of the Sierra Nevada, and on the other the ranges of the Coast Mountains, stretched out towards the north until their remote peaks were lost in the smoky distance. They seemed like great arms holding the semi-desert plain and its shallow lakes between them. The two small lakes, Buena Vista and Posuncula lakes, were distinctly visible below, and the long line of timber on the sloughs of Posuncula river lay spread out before me as if on a map. The direction of the centre of Posuncula lake was roughly taken by compass, and found to be N. 5° W., and Buena Vista lake N. 40° W.

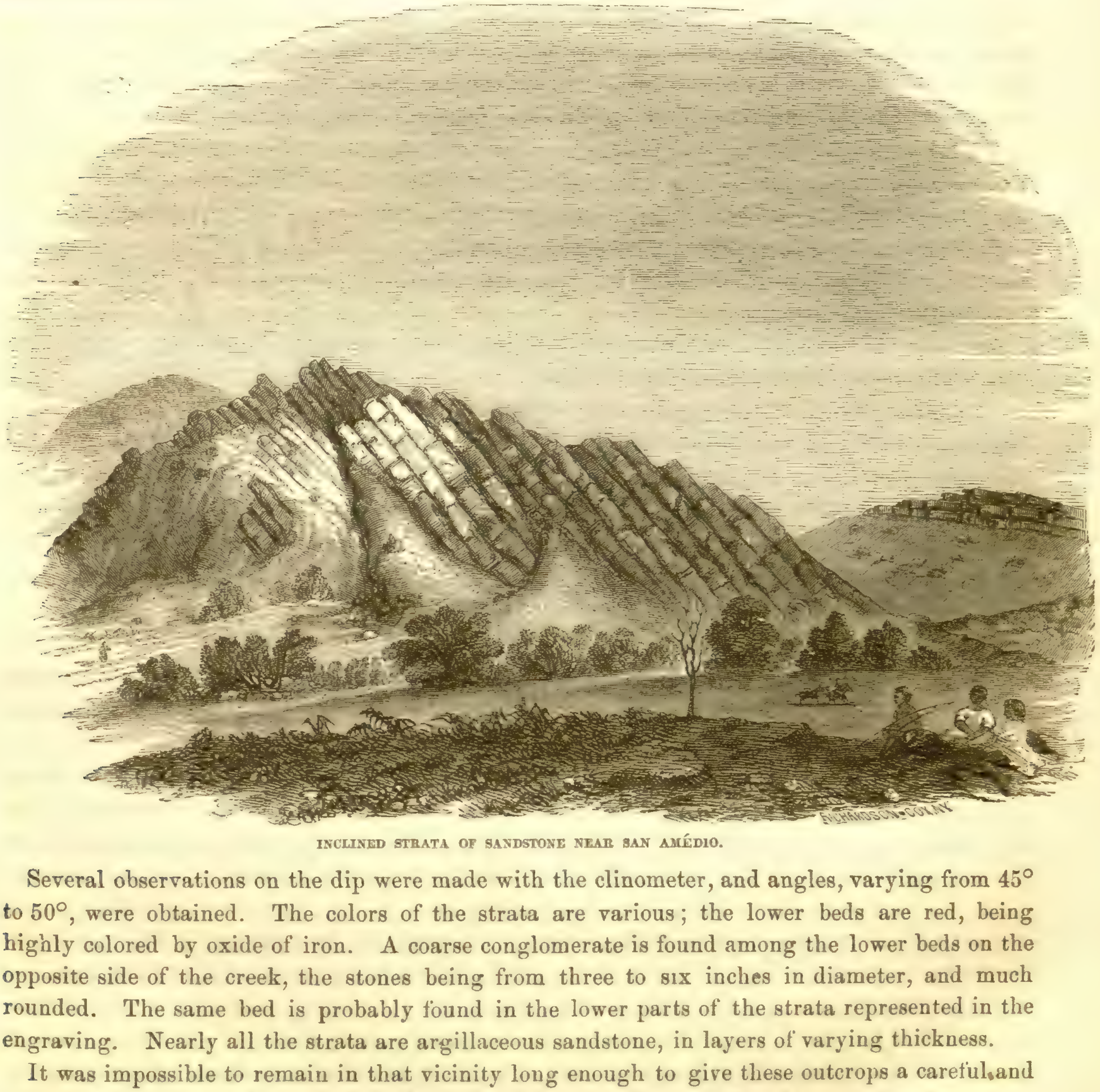
The first ranges of heights of the Coast Mountains were readily overlooked, and a broad valley, or basin, was seen to extend between them and the next range, or the hills on the west. This basin appeared to be the bed of a dry lake; it much resembled those seen in the Great Basin from the summit of the Tejon Pass. The whole region seemed peculiarly brown and barren. The direction of this plain or dry lake, by compass, was N. 80° W. The Tejon was in full view, and the following bearings were taken: Depot camp, or its vicinity, N. 47° E.; Adobe house, N. 46° E.; summit of the ridge on the north side of the entrance to the Tejon Pass, N. 55° E. These bearings are all approximate, having been taken by a compass without sights.

The northern slope of the mountain is much less abrupt than the southern, which may be called precipitous, and is well timbered with pine trees even at the summit. No outcrops of ore could be found on the summit; but the rocks themselves do not appear, being covered by soil and roots of vegetation. A small mass of the ore was lying on the ground, and evidently had been broken up by some explorer. No part of the vein exhibited distinct traces of mining

operations, and it is probable that the ore used in the furnace was obtained from the debris in the ravine.

After obtaining specimens of the ore and the adjoining rocks, we returned to the camp-ground of the previous evening and again encamped.

September 22.—We returned towards the Cañada de las Uvas by the same trail, and, soon after leaving camp, passed the great outcrop of sandstone strata seen on the afternoon of the 20th. The highest part of this series of strata was estimated to be over five hundred feet above the level of the creek. The accompanying wood-cut will show the character of the strata and their inclination.



INCLINED STRATA OF SANDSTONE NEAR SAN AMÉDIO.

Several observations on the dip were made with the clinometer, and angles, varying from 45° to 50°, were obtained. The colors of the strata are various; the lower beds are red, being highly colored by oxide of iron. A coarse conglomerate is found among the lower beds on the opposite side of the creek, the stones being from three to six inches in diameter, and much rounded. The same bed is probably found in the lower parts of the strata represented in the engraving. Nearly all the strata are argillaceous sandstone, in layers of varying thickness.

It was impossible to remain in that vicinity long enough to give these outcrops a careful and critical examination. I searched for fossils, in the hope of determining the age of the formation, but without success. It is much more consolidated than the Miocene formation along Ocoya creek, and the disturbed and uplifted condition of the strata indicate a different age. The lower

hills have a different appearance, and more nearly resemble the Ocoya creek beds; they are similarly cut by numerous dry ravines; and high banks, or vertical cliffs, have been formed by floods, showing that the strata are soft and unconsolidated. They present alternations of white and buff-colored clays, with red layers, containing a large portion of oxide of iron. By the action of the weather, these clay-cliffs are worn into fantastic forms; and at one locality, I saw the most extraordinary combinations of conical peaks rising, one above the other, to sharp points, like church steeples; at a short distance they looked like a forest of spires.

These soft strata are very probably of the same age as the Ocoya creek formation, and the harder and uplifted strata nearer the granite are probably older.

When we arrived opposite the high cliffs of sandstone, several mountain sheep were seen among the rocks, and others were afterwards observed several miles lower down in the valley. It is probable that they are numerous in that vicinity, it being rarely visited by hunters and others. On our return through the valley where so many bear tracks were seen, we ascended a high hill and reached a high, open space well covered by grass. José soon discovered two or three deer at a distance, and succeeded in killing one. Game of all kinds is peculiarly abundant here, the high grassy valleys and the secure retreats among the rocks being very favorable.

We reached the entrance of the Cañada de las Uvas about sundown, after a long and fatiguing ride, the sun's rays being exceedingly hot and oppressive at the foot of the hills, where there was but little or no wind.

September 23.—We left camp and travelled over the same trail we followed on the 20th, and reached the depot camp at the Tejon in the afternoon.

The Indians of the Tejon make beautiful baskets, or shallow trays, out of a round wiry grass, which they wind and weave together very dexterously. The grass is stained with different colors, and is worked in so as to produce different geometrical figures. These baskets are highly valued, and are used to contain food after being cooked, or even to boil water in by means of hot stones, the weaving of the grass being so close that they are completely water-tight. They last for years, and are called *coritas*.

CAÑADA DE LAS UVAS.

September 29.—Started with the party to survey the Cañada de las Uvas. Large boulders and erratic masses of rock were found all along the banks of the Tejon creek, as far as the adobe house.

At the entrance of the Cañada, the abundance of boulders along the little creek which flows out from the pass, gave good indications of the rocks exposed along its sides. This accumulation has already been noticed, but at this visit a greater variety of blocks of granite, syenite and metamorphic rocks was found. A boulder of sandstone was also found, filled with fossil shells, beautifully preserved. The shells were white, and looked as fresh and solid as if taken from the water but the day before. The mass was broken up and several species obtained and preserved.[1]

The first outcrop of rock is granitic or metamorphic, the rock being traversed by lines of structure. It contains a large amount of dark-green mica, to the apparent exclusion of hornblende. Veins composed almost wholly of mica, in small scales, were also seen; these were so black as to resemble strings of hornblende or iron ore. A white, silvery mica was also found beyond. The Cañada is bounded by high hills or mountains, perhaps 2,500 or 3,000 feet above the trail, and the sides are very precipitous. The botton of the ravine is filled with a thick accumulation

[1]These have been examined and reported on by Mr Conrad. See Appendix, Article II, and Chap. XIII.

of drift and debris, mingled with earth, through which the creek has cut a channel, and thus formed a terrace or bench on each side, between it and the high mountains. There is very little timber on the hills, so that the whole surface was exposed to the sight, and the outcrops of rock could be noted here and there. Between these outcrops there were broad patches of good soil, which supported a scanty growth of grass and an occasional oak.

The high hills on each side, presenting occasional outcrops of granitic rocks, were found to extend for four or five miles from the entrance; the valley then becomes more open, and the granite ridges lower, and nearly covered by a loose sedimentary formation resembling ordinary drift, but containing more clay. The surface of the valley is covered with a luxuriant growth of grass, and a deep soil supports groves of magnificent oak trees, some of them eight feet in diameter. A small brook of pure and cold water was found here, and our camp was on its borders, under the branches of the large oaks, while those branches that had fallen, or been broken off by bears in gathering acorns, furnished fuel for the fires. While we were encamped here an unusual number of grizzly bears were seen. They frequently came to the water to drink, in the evening, just after sunset. One of the large oaks bears the following inscription, cut deeply into the hard wood: "Peter le Beck, killed by a bear, Oct. 17, 1837." A broad, flat surface was hewed upon the trunk, and well smoothed off before the letters were cut. It is a durable monument.

September 30.—The valley widens out beyond camp, and a broad plain, covered with grass, is bordered on each side by oak groves extending for miles.

Several outcrops of limestone were found near the commencement of this plain, and they appear to extend across it obliquely, the rock being found in the ridges on each side. Another outcrop was found at the eastern extremity of the plain, and on the north side, at the termination of the range of hills. The surface of these hills is rounded and appears barren; but few outcrops of rock were observed.

Salt pond, or Casteca lake, (dry.)—At the eastern end of the grassy plain the pass deflects towards the south for a short distance, and then again extends east and west. A narrow path or trail, however, extends over the hills in a more direct line, and passes by the dry bed of a small lake or pond whitened by a solid incrustation of *salt.* This salt had evidently been left by the evaporation of water, which probably collects there to a depth of several feet during the rainy season. The salt forms a perfectly white crust, in some places two or three inches thick. It looks like a snow-field, and bears a strong contrast with the dark-green foliage of the oak timber growing near the shore. The winds, as they course along over this smooth, unobstructed surface of salt, loosen large quantities and throw it into drifts, or raise it in clouds and small whirlwinds, that dance lightly from shore to shore and fill the air for a great distance to leeward of the lake, distributing it in a fine powder over the adjoining hills, and salting whole acres of vegetation.

This salt is probably derived from the Tertiary sediments that abound in the vicinity, and is dissolved out by the percolation of surface water and by springs. As the lake is a common receptacle for the drainage of a large surface of this formation, and has, apparently, no outlet, it is doubtless the case that this quantity of salt has been gradually accumulating; the waters becoming annually more and more highly charged, and consequently a larger quantity of salt crystallizing with each successive evaporation.

In this way, interior fresh water lakes may gradually become salt, merely from the supply

received from the strata of a recent marine formation, and not necessarily from the evaporation of a larger body of salt water left by a retiring ocean.

I found that the salt of this little lake was exceedingly bitter and nauseous ; probably owing to the presence of a large proportion of chloride of magnesium. Plants, similar to those that flourish luxuriantly on the seashore, were growing around the margin of the lake-bed. A specimen of the plant most abundant at the border of the salt is, according to Dr. Torrey, *Shoberia calceoliformis*, of the natural order of *Chenopodiaceæ.* I also obtained a species of *Salicornia*, apparently *S. fructiosa.*

Although the lake is small and insignificant, compared with the salt lakes of the Great Basin, it is a good illustration of the formation of beds of salt.

Granite and Volcanic rock.—I followed the trail around the margin of this field of salt, and left the valley of the pass and the main party. The trail led for some distance between a high hill and the salt, and then followed a long, narrow valley between the hills, among groves of oak. The path was very dusty, and apparently much travelled, but the mule was very unwilling to keep it. I soon found it to be a *bear trail,* and full of recent tracks of great size. After pressing forward with caution for about half a mile, the mule suddenly stopped, and I discovered a gigantic grizzly bear, with three cubs, slowly mounting the hill on the left, and about one hundred yards distant. Seeing me stop, she halted, and, partly turning, uttered a low growl, which I did not wait to hear repeated, but gained the top of the hill on the other side as quickly as possible.

On regaining the trail which leads over the summit, through a slight depression, a large wooden cross was found planted in the ground on the summit, at the right. From this point there was a fine view of the eastern end of the valley of the Cañada, nearly to its opening out upon the broad region of the Great Basin. No outcrops of rock could be found at the summit of these hills ; the surface everywhere was rounded, and the soil was sandy. On descending, however, on the opposite side towards the valley, outcrops of white and fine-grained granite were found. A fine spring was found half-way down the hill, and at the point where the trail enters the valley there are two or three small ponds of water partly surrounded by reeds. A number of ducks were found here. Granite outcrops were found for two or three hundred yards, and it then gave place to a hard, reddish volcanic rock, apparently a dyke. Sandstone in inclined beds was seen beyond, the trend being nearly east and west, and the dip northwards about forty degrees.

At this point of the pass, and eastward towards the Great Basin, the country opens into a succession of low hills, with rounded outlines, characteristic of the sandstone and drift formation. The last is well developed on the right or south side of the valley, near the Los Angeles trail, where numerous vertical exposures of the strata are produced by the wearing action of small streams descending from the surrounding granitic heights. These hills of horizontal sediment are composed of water-worn masses of the adjoining granite and limestone, and the subjacent rocks. They present some peculiarities of stratification that indicate an origin more recent than the sandstone of the Tulare slope of the Sierra. Several miles beyond, and near to the Great Basin, several outcrops of sandstone, with inclinations at various angles, were found. At one place the sandstone was coarse, very hard, and associated with a bed of conglomerate. The trend was nearly east and west, and the strata on edge. The hills on the left or north side become lower, while those on the right side of the valley retain their elevation, and appear to be

succeeded by granitic or other hard rocks beyond. It was not possible to determine whether the strata of these hills were all upraised ; the soil was deep and generally obscured the rocks.

On reaching the outlet of a small brook or rivulet, coming in from the mountains at the south through a slight valley between the hills at the eastern end of the pass, we turned up and encamped a short distance above. The rivulet did not flow far below its source, in a spring just above the camp, but there was an abundance of water and grass, and oak trees, most of them the evergreen variety, with the spinous leaves and slender, pointed acorns, (*Quercus agrifolia.*) The hills, at the point where we turned and entered the valley, appeared to consist of upraised sandstone alone ; but higher up, a red eruptive rock, trappean and amygdaloidal, made its appearance in extensive outcrops. It appears to form both sides of the valley.

A large outcrop of sandstone strata is found not over two hundred yards from the northern margin of this volcanic rock. They trend northeast and southwest, and dip at the angle of 54 or 55 degrees, and in one place present bluff edges favorable for obtaining a sectional view. A portion of this section, about six hundred feet in length, is represented in the annexed cut.

SECTION OF SANDSTONE STRATA NEAR CAMP.

a Bed of flint, probably fossiliferous. *b* Silicified stems of plants.

The strata consist of coarse-grained, light-colored sandstones, containing pebbles and layers of conglomerate, made up of fragments of granite and volcanic rocks of various shades of texture and color. Some of the pebbles are red, and others have a delicate lilac tint, with numerous imbedded crystals of white feldspar.

At the point marked (*a*) in the figure there is a thin bed of rock containing small fragments or masses of dark flint, probably fossiliferous. A short distance from this, at the point marked (*b*), a bed, five or six feet thick, appears, which is filled with silicified organizations similar to those found in the boulder on Posuncula river. (See Chap. IV.) This bed was almost wholly formed of the fossils ; they were of various sizes and thickly pressed together. [1] This stratum was succeeded by one of dark flint, three feet thick, beyond which the coarse sandstone again appeared. This sandstone does not present any distinct evidences of metamorphism, but it is more compact and consolidated than other outcrops farther removed from the intruded rocks. The trend of the outcrops of fossiliferous flint did not correspond with that of the strata of the higher part of the outcrop ; it was more northerly, probably being less than 25° east of north. The dip, also, although greatly obscured and not favorably shown, appeared to be different, being at a greater angle, nearly vertical, or inclined slightly to the west. It is possible that the strata in this outcrop dip in two directions, forming a synclinal axis ; but, as it was not possible to determine this during the short time in which they were examined, they are represented in the section as dipping in the same direction.

During our stay at this camp two bears were seen, and one came nearly to the spring to drink, but, seeing one of the party, hastily retreated through the bushes.

October 4.—On returning to the Tejon, through the Cañada, the rocks were more thoroughly examined, and the valley of the pass was followed, instead of traversing the hills near the salt lake. An outcrop of sandstone along the trail, and about two miles from the camp, is chiefly

[1] Nearly all the specimens from this bed were lost.

composed of the debris of granite and similar rocks. Some included masses or boulders resemble sandstone. The trend is about north and south; dip westward 50°. These strata are soft and wear away rapidly where they are exposed. The outcrops of sandstone, near the two small ponds, were again observed with the same result as before—dip north at an angle of 40 or 50 degrees.

The intrusive rock or dyke was found to extend towards the summit and at the base of the high granitic hills on the north side. Ridges of limestone, white and crystalline, were also found at the summit, and the trail passes between two of them. There is much debris of this limestone scattered about, and among it I found masses of a black ore, which attracts the needle strongly, and is probably ordinary magnetite or magnetic iron ore; it, however, does not exhibit cleavage, or break like the ore. The outcrop of this ore was found on the top of the ridge, and is about three feet thick, trending nearly east and west; dip nearly vertical; limestone bounds it on each side. From this point the trail descends rapidly to a dry water-course, extending nearly north and south, or towards the small salt lake called Casteca Lake.

Strata, probably Tertiary.—Passing along the dry channel towards the north, we found the hills on the left to consist of horizontal strata, exposed in many places, high up and inaccessible, by slides or ravines cut by the rain. These exposures revealed the presence of several colors in the strata—yellow, bluish, green, and other tints. They seemed to be chiefly marls or clays, and very soft. A thickness of two or three hundred feet, at least, was visible.

October 5.—Encamped last night at the "bear camp," (as we have called the camp where the inscription in memory of Peter Le Beck occurs,) and this morning left for the Tejon. Additional observations were made upon the geology along the trail, but no outcrops of sandstone, similar to that containing the fossils picked up at the entrance of the Cañada, could be found.[1]

[1] Further observations on the geology of the Cañada de las Uvas will be found in Chapter XV.

GREAT BASIN FROM THE SUMMIT OF TEJON PASS

CHAPTER VI.

TEJON TO THE GREAT BASIN AND PASS OF SAN FRANCISQUITO—PASS OF SAN FRANCISQUITO TO THE MOJAVE RIVER.

Tejon pass.—Granitic and metamorphic rocks.—Slope of the basin.—Yucca trees.—Tertiary.—Lost mountains.—Spring.—Porphyry.—Spring resorted to by Indians.—Horns of the mountain sheep.—Dry lake-bed of clay.—Granite forming lost mountains.—Transverse chain of mountains forming the southern boundary of the basin.—Pass of San Francisquito.—Upraised strata, brecciated.—Volcanic rocks and obsidian in the strata.—Foot-hills of sedimemtary rocks.—Antelope.—Granite.—Lake Elizabeth.—View from the summit of the pass.—Granitic and metamorphic rocks.—Upraised sandstone, probably tertiary.—Talcose and auriferous slates.—Gold.—San Francisquito pass to the Mojave river.—Cow camp.—Hornblende and mica slate.—Hills of horizontal strata.—Fertile valleys.—Slope of the great basin.—Plants.—Mojave river.—Granitic and metamorphic rocks.—Alluvium.

TEJON TO THE GREAT BASIN AND THE PASS OF SAN FRANCISQUITO.

On the 10th of October I accompanied Lieutenant Williamson on his trip through the Great Basin towards the Mojave river. The wagons and the main body of the Expedition had been sent forward by way of the Cañada de las Uvas, and were to wait in one of the grassy valleys near the Pass of San Francisquito.

We travelled through the Tejon Pass, and a fine opportunity was thus presented for repeating and comparing the observations upon its geology previously made. Granitic and metamorphic rocks were the only formations visible, except a thick accumulation of rudely stratified drift or detritus, which rests in the bottom of the valley and is cut by the channel of the creek at one side, parallel with the pass, and by side ravines from the high ridges. At the summit, a fine view of the bare and arid surface of the Great Basin was obtained. The level surface of a dry lake, or extensive pond, was plainly visible, and most persons would have regarded it as a sheet of water. The range of mountains bounding this part of the basin on the south, and separating it from the Pacific slope, were also in full view, and could be traced westward for a great distance.—(See View V.)

These mountains trend in a direction nearly at right angles to the Sierra Nevada, forming a *transverse chain*, uniting with the southern end of the Sierra at the Cañada de las Uvas. Their northern slopes appear barren and nearly without trees.

We passed nearly half-way down the descent towards the Basin, following the wagon road, or trail, and not the ravine which was surveyed a few weeks before. Most of the rocks were hid from view by the soil, but those that appeared at the surface were similar to the outcrops in the ravine, which, indeed, is but a short distance further south. Encamped at a spring on the hill-side among some oak trees. The vegetation is not so dense on this side of the mountains as the other. Temperature at 7 P. M., 56°; at 9 P. M., 54°.

October 11.—Temperature at daylight 49°. The night was cold. On reaching the lower hills, near the margin of the broad slope of the Basin, a succession of outcrops of granitic and metamorphic rocks was passed. Portions of the exposures resembled the micaceous granite of

the summit; but beds of a hard, compact, and slaty rock, composed chiefly of hornblende and black mica, were found to alternate with it. One of these hard beds greatly resembled a trappean rock, being black and very dense. Veins of carbonate of lime were found traversing it irregularly, looking as if they had been intruded. The mineral was not lining fissures, but formed a part of the rock. Ridges of white limestone were found in the vicinity.

The slope of the Basin is a broad, gently inclined plain, reaching out with a nearly uniform descent for several miles without any obstruction. The creek flowing out from the ravine of the pass on the east side has cut a long valley in this slope, extending for several miles below its general surface. We travelled in this valley; and the view on each side was bounded by banks, of nearly uniform elevation, looking like terraces. These banks were from fifty to one hundred feet high, the elevation decreasing towards the lower part of the valley. The width of the valley varies from one-eighth of a mile, or less, to half a mile. Occasional exposures of horizontal or gently inclining strata could be seen, but they were much obscured by the talus and earth broken from the sides and forming a slope to the bank. No satisfactory section could be made, nor even the lithological characters of the beds determined. The upper portions of the slope are undoubtedly formed of loose and irregularly stratified sand and gravel, derived from the elevated ridges and cañons of the mountains, and spread out upon the slope as if they had been laid down under the sea, or were formed by its action into a broad, gently shelving beach.

It is probable that Tertiary strata are exposed along this channel in the slope, but I did not succeed in finding any organic remains indicative of the age of the strata. The vegetation in the valley was remarkable and extraordinary in its appearance, consisting entirely of the straight trunks of the yucca, which grew very thickly in several places, and at a distance looked like bands of Indians. The leaves are about as strong and sharp as a bayonet, and it is commonly called the *bayonet tree.* A view of the valley and these yucca trees is given in Chapter XVI, View XI. By ascending from the bed of the little creek to the top of the banks bordering the valley, it was found that the channel was merely a groove, if it may be so called, in the broad slope of the Basin, and on receding from it for a short distance it became invisible, and its existence would not be suspected; the country seemed an unbroken plain.

Several miles towards the north, hills of horizontal strata of clay and sand were visible, and they looked like the formation along Ocoya creek. These hills are near the entrance to Tah-ee-chay-pah Pass, and they are probably Tertiary.

Lost Mountains.—The ridges and mountains which were visible from the summit of the Tejon, and which diversify the surface of the Basin, do not appear to form continuous ranges, but are isolated, standing apart, and separated by broad slopes. The nearest hill of this description appeared to be about ten miles distant, and we travelled towards it. The surface of the plain was gravelly and not covered by grass, but here and there an isolated and dried tuft called "bunch grass" could be found, and was much desired by the mules. A great variety of thorny shrubs was also found, and yuccas standing alone at intervals gave a peculiar aspect to the scene.

The peculiarly arid and desert-like surface gave us little reason to expect to find springs of water, and yet it was reported by the Indians that they could be found about the lost mountains. After travelling about eight miles north-east from the foot-hills of the Sierra at the Tejon, the surface became gently undulating, and a green spot could be seen about a mile from the base of the first lost mountain. This proved to be a fine spring, surrounded by a thick growth of

grass. This grass formed a circle about the water nearly thirty feet in diameter, and grew so thick and long that the ground was completely hid from view. The water was also partly overshadowed by a shrub. The surface about the spring was slightly elevated so as to form a mound, the water being in the centre. This elevation may have been formed by earth and sand raised up from below by the water, or the moist, grassy surface may have retained sand or dust blown about by the wind. The roots of the grass and the decaying stalks have also promoted this accumulation. Temperature of the water 64°, air 90°, 1 P. M. The surface, for several hundred feet around, gave indications of the presence, at no great distance below, of strata of clay: these, perhaps, have forced the water above the surface. No good exposure of the beds was found, the superficial covering of gravel and sand being very thick and hiding them from view. The rocks composing the ridge were not exposed at the spring, but were over a mile distant. On leaving the spring to pass further east, we did not pass sufficiently near these rocks to determine their character satisfactorily; but the fragments which had been washed down upon the slope consisted of porphyry and dense agate-like masses, delicately banded or striped like jasper. In some fragments the layers resembled stratification.

About six miles beyond the first spring we found a second, on the slope of another ridge. We encamped at this spring about sunset, and there was little opportunity to examine the rocks, which rose up in long linear outcrops around. They seemed to form a series of narrow ridges; and between them, at one point, there were appearances of compact and very hard horizontal strata. The general trend of the mountain is N. 25° W. (magnetic.)

October 12.—At daylight the thermometer indicated a temperature of 40°, and for the water of the spring 60°. On the further slope of the mountain another long line of outcrops was observed, the trend being N. 50° W.; the exposure was, however, on a slope, and the trend may be parallel with the outcrop noted yesterday evening. The rocks were very peculiar, and so different from any commonly known that it is difficult to describe them. A great part of them were very hard and chert-like, but had the color of serpentine. Every step brought me to phenomena which defied immediate explanation, and not only excited great interest and curiosity but deep regret that it was impossible to devote more than a few minutes of the early morning to their examination. It is most probable that erupted rocks occur here in connexion with metamorphosed strata of several colors. At the north of this ridge, and at the distance of two or three miles, we saw the exposed edges of strata in the sides of other ridges. The strata appeared to be nearly horizontal, and were variously colored, red and white, looking as if they were formed of clay.

The only green vegetation about the spring was a margin of grass, about three yards wide; and the water lay exposed to the full glare of a scorching sun.

This spring had evidently been long resorted to by the bands of predatory Indians who formerly made constant inroads upon the settlements of the Pacific slope, and drove off horses and cattle. Bones and skulls of horses lay around the margin of the spring—relics of the feasts that had been enjoyed by the successful thieves. We also found the large horns of the mountain sheep lying on the ground.

We continued our journey eastward from the camp with considerable rapidity, and during the day passed along the base of a ridge which is composed of erupted rock of a red or chocolate-brown color, and is porphyritic. It was completely bare of vegetation, and the highly-colored cliffs rising above the arid surface presented a desolate volcanic appearance under the rays of an unclouded sun. A striped or belted character was distinctly presented by the greater part

of this rock, the lines being very near together and generally of different colors. It is compact and porphyritic; the crystals disseminated in it being small and white, resembling feldspar.

After passing this ridge, we travelled for several miles on the surface of the dry lake which was visible from the Tejon pass. This consists of a perfectly level and floor-like bed of clay, so hard that the mules left scarcely any tracks upon it. It extended for miles; and the pellicle upon the surface being exceedingly fine and polished the distant portions appeared like water, and the mountains and other objects were reflected as if from a mirror. It reminded me of the frozen surface of a lake.

At the further extremity of this dry lake, or on the margin of its widest portion—for it appeared to be prolonged further east and north—we reached another series of lost ridges. As we approached them, the ground was found to be strewn with a pink gravel, which consisted of angular fragments of feldspar of that color, and indicated that the ridges were granitic. This was found to be the case, the rock being a gray granite, traversed by large veins or masses of pink feldspar, or granitic veins, in which this feldspar was the predominating constituent. These veins were so large and numerous in some places that they could easily be mistaken for the principal rock of the ridge. Their direction appeared to be variable: one had a trend of N. 36° W.; a second, N. 14° E.; and a third, N. 66° E. The granite which is cut by these veins has an even texture, and contains a large amount of feldspar; it decomposes into granular masses, which may be crumbled in the hand. Numerous little peaks were formed by the projection of limited exposures of granite above the general surface of the Basin, and a corresponding number of little valleys or basins was inclosed by them; so that the general character of the surface of the Great Basin was represented in miniature. We traversed a considerable area among these outcrops of granite, and occasionally found large blocks of it standing out upon the surface, the surrounding rock being covered from sight by a thin layer of feldspathic gravel. One of the highest points that we reached presented an almost vertical bluff, five or six hundred feet high towards the north, and was surrounded on all sides by a regular slope. This being the most elevated point in that vicinity, we had a fine view of the surrounding country. On the south, at a distance of twenty-five or thirty miles, we could see the blue summits of the transverse chain of mountains forming the southern boundary of the Basin; and on the west the lofty ridges of the Sierra Nevada—the intervening country being a treeless desert. Towards the north the eye could roam among countless lost mountains rising like the waves of the ocean in a storm, presenting a constant succession of peaks, until, by their number, they appeared to form a continuous range.

Several peaks, at a distance of forty or fifty miles, had a peculiar conical form, having flattened tops, suggestive of volcanoes, but there was no opportunity of verifying such a supposition. They may be the remnants of elevated plains of sedimentary origin, or of overflows of lava or basalt.

We returned from this point towards the first spring, nearest the Tejon Pass, and on the way back found one or two additional but smaller springs, one of them on the border of the dry lake at the base of the bluff of porphyritic rocks.

October 13.—We left the spring, and, instead of following our trail back to the Tejon Pass, struck across the plain of the Basin, in a southerly direction, towards the entrance of the Pass of San Francisquito. This is in the chain of mountains extending a little south of east from the Sierra Nevada to the peak of San Bernardino, at the source of the Mojave river. This chain

appears to be prolonged to the westward of the end of the Sierra Nevada, and forms the southern end of the Tulare valley, perhaps extending to Point Conception on the coast, this being in the line of trend. The direction of this chain is, therefore, nearly transverse to the general direction of the Sierra Nevada, and it has already been noted as the *transverse chain*. Although this difference in the direction of the two chains is not very apparent to the observer when in the Cañada de las Uvas, or when travelling southwards from the Tulare valley to Los Angeles or the San Francisquito Rancho, it becomes very striking when he passes out upon the surface of the Great Basin, and can view the Sierra Nevada and the transverse chain at the same time. The Sierra Nevada, when seen from the Basin, appears to extend in a meridional direction and to be joined by the other chain at right angles. As the peaks and ridges of the transverse chain are not covered with snow except in the winter, it cannot be included with the Sierra Nevada, and known under the same name. It is also separated or made distinct from the Sierra by its direction, and from the ranges called "*Coast Mountains*," both by position and geological structure. The rocks composing it are similar to those of the Sierra Nevada, and it should be regarded as a prolongation of that chain, and not of the Coast Mountains. As the most prominent and well known peak of the transverse chain is named San Bernardino, I shall refer to the chain in the succeeding descriptions as the *Bernardino Mountains* or *Bernardino Sierra*,[1] meaning the east and west ranges of mountains between San Bernardino and the end of the Tulare valley, or beyond, to the western limit of the granitic rocks.

PASS OF SAN FRANCISQUITO.

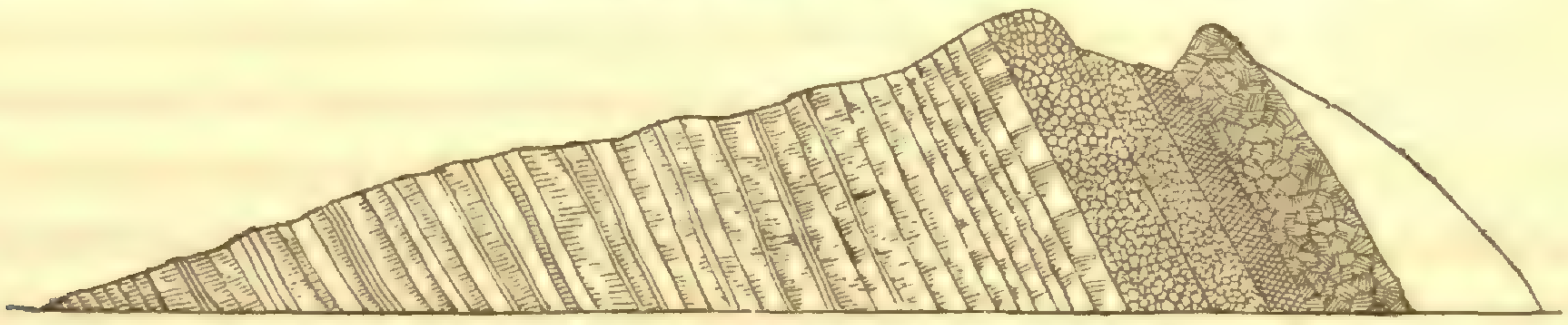
The entrance or approach to the Pass of San Francisquito from the surface of the Great Basin is not marked by any peculiar or striking topographical feature. The outline of the mountains is very uniform, and not marked by any great depression or high peaks. It is, however, very probable that a long ridge which intervenes between the Basin and the main ridge of the mountains hides the full outline from view. The slope of the Basin is very regular, and rises without any great undulation from the dry lake or hard clay surface at the lowest point of that part of the Basin to the foot-hills of the pass. This slope is dotted on its upper portion by the thorny yucca tree, which here and there forms thick clumps or groves, or they stand singly, rising to the height of a man, and bearing such a close resemblance to men in size and position, that they often deceive one for a moment when they are viewed from a distance.

Foot-hills of the mountains,—Remarkable brecciated strata of volcanic rocks.—The first hill or rise of the surface, near the entrance to the pass, stands alone, as it were, about five miles distant from the main mass of mountains, and is separated from them by a continuation of the Basin-slope. This hill rises to an altitude of about 300 feet above the slope, and is composed of highly inclined strata, very regularly stratified, trending north 30° east, with a north-westward dip. The lower parts of the hill are composed of sandstone strata of a light color, but the higher portions consist of remarkable beds of volcanic materials, regularly stratified, but dipping with the sandstone. These beds contained porphyries of great beauty, in large blocks and boulders, all firmly united together.

[1] For a note explanatory of the use of the word *Sierra*, see Chapter XI.

The following section, representing a thickness of not over five hundred feet, will serve to indicate the relative positions and dip of the strata:

SECTION NEAR THE PASS OF SAN FRANCISQUITO.



a. Stratum, containing large angular blocks of red and lilac-colored volcanic rocks—trachytes and porphyries.

b. Six to ten feet thick, compact rock, of a vermillion red color.

c. Breccia of small fragments of porphyry, serpentine, and a jaspery rock, imbedded in a white paste or matrix. Thin seams of opalescent quartz traverse this bed.

d. A rude mixture of large, well rounded, and evidently water-worn boulders of trap rock, porphyry, trachyte, and other volcanic rocks, of various shades of color and variety of texture.

e. Thin layer of angular fragments of obsidian, eight to ten inches thick.

The strata between the conglomerate and breccia and the layer of obsidian consist of nearly white, fine-grained sandstone, the strata of which were not, however, fully exposed to view. The layer of obsidian formed a distinct dark stripe along the base of the series, and was slightly broken and faulted in several places.

This was a remarkably interesting and singular accummulation of volcanic material or debris; and it was a matter of regret that I could not even spend an hour in giving it a detailed and careful examination, of which it certainly is most worthy, if for no other purpose than to study the extraordinary beauty of the great variety of volcanic rocks brought together in a manner so peculiar. It is possible that the highly inclined condition of the strata can be referred to a granitic intrusion in the mountains, but I am more disposed to refer it to some local intrusion of trap or porphyry which was not seen.

Beyond this hill, we crossed several with rounded surfaces, but without seeing any rocks, and then reached the foot-hills of a granitic ridge trending parallel with the main chain, thus forming the northern boundary of a long valley. These foot-hills were not much elevated, and although nearly without timber or brush, are soil-covered, and support a growth of grass, which probably gives a cheerful green aspect to the surface in the spring and early summer, but which, in the fall and winter, assumes a sombre, uniform brown, or arid appearance. They have rounded surfaces, and appear to be formed of sedimentary rocks, although outcrops were not seen. As we passed over and among them, we came suddenly upon a large herd of antelope, quietly feeding in one of the depressions and on the hill-sides. There were probably not less than one hundred and fifty in the herd; and, as soon as we were discovered, they bounded away most beautifully, and quickly disappeared over the top of the hill.

Granite.—We passed from the rounded hills to the base of the ridge, which is formed of granitic or metamorphic rocks. Its surface on the northern side is, however, smooth, and nearly without trees or shrubs. These make their appearance, however, in the little valleys and depressions, especially where the ground is moist or springs issue. The underlying granite was not well exposed; the soil was deep, and only an occasional outcrop was found. The rock, where seen, was hard and compact, and of a light-gray color. The minerals were disposed in lines, and the trend was found to be N. 110° W. A broad cliff of this granite, with a bold, vertical face, near a spring, was covered over with strange hieroglyphic characters, the work of Indians, probably, many years before. One of these characters was like an anchor in form, and

another appeared to represent a long chain with a ball at one end, surrounded by rays, like our representations of the sun.

The southern side of this ridge was found to support a sparse growth of timber, and the opposite heights of the main chain were seen to be thickly covered with a growth of green *chamizal.* The arrangement of the mineral of the rock of this ridge, and its entire difference in appearance from the granite about to be described, have led me to regard it as metamorphic, and I have so indicated it on the section.

Valley of Lake Elizabeth.—Descending the southern side of the ridge, we passed into the long valley between it and the main chain. Turning up the valley to the right, we soon reached the borders of a very beautiful sheet of water—Lake Elizabeth. This valley extends towards the Cañada de las Uvas, and we found the trail made by the wagons in their passage from there to the lake. The position of the valley and the lake will be seen by referring to the small geological map of the Tejon and its vicinity, (Chapter XV,) and to the section of the Bernardino Sierra. The valley is comparatively narrow and long, and is about 3,300 feet above the sea. It is well watered, and produces an enormous growth of grass, where herds of deer delight to congregate, not only for food, but for the shelter from view which the tall grass affords.

We encamped on the borders of the lake, and during the night the temperature fell to 29°, and 32° at daylight. Thick ice was formed. It is probable that considerable snow accumulates in this valley during the winter.

October 13.—We returned on our trail through the valley, about eight miles, to the entrance of the Pass of San Francisquito. Between the lake and the pass there is a line of hills, of moderate height, composed of sedimentary strata, probably horizontal, but which were not well exposed at any point we passed. These strata are chiefly of coarse sandstone, of a light-gray color, containing a large amount of the debris of white granite, and, in some places, in such quantity as to resemble, in composition, granite itself. This same formation extends through the valley several miles to the eastward, and is probably Tertiary. The ascent from the valley of Lake Elizabeth to the summit-level of the pass is short, and no interesting exposures of rock occur. The underlying formation consists, however, of a white granite, in which white feldspar or albite, and quartz appear to be the predominating constituents, forming the binary compound called *pegmatite.* This rapidly decomposes, and furnishes a rich soil, which sustains a vigorous growth of chamizal of dwarf oaks on the slopes, and large evergreen oaks in the valleys and cañons of the south side, where there is more moisture and a greater depth of earth.

The view to the southward, presented from the summit of the pass, is peculiarly beautiful. The gorge or valley of the pass is almost transverse to the trend of the main chain ; the observer can thus overlook its subordinate ridges, and from the great elevation see beyond them to other ranges nearer the Pacific. Perhaps at favorable seasons the ocean itself may be seen in the distant horizon. The width of the mountain chain at the pass being over twenty miles, the ridges are seen in succession coming down to the ravine of the pass, becoming more dim and faint in the distance, until their outlines are blended with the distant haze, resting over the heated valleys and plains of the coast-slope. The aspect of the landscape from this point was changed from that of the Basin not only by a modification of the topography, but by the presence of vegetation of various kinds, more agreeable to the eye than the strange, thorny plants of the Basin, with which they contrasted very strongly. We encamped in the evening a few miles below the summit, at the side of a spring of good water, bordered by a growth of high rushes,

grass, and aquatic flowers. Our blankets were unrolled under the wide-spreading branches of an evergreen oak; its huge trunk, already half burned away by previous camp-fires, served as our fire-place, and the hollow part above made a perfect chimney. Here, after a day of toil and fatigue, we enjoyed a hearty supper on choice cuts from a fat buck, and on teal ducks from the lake, both provided by the rifle of our friend Ridley, who had accompanied us from the Tejon.

Summit-level of the Pass to the San Francisquito Rancho.—No strata of sandstone or clay were seen in the neighborhood of our camp near the summit. The white granite appeared to predominate, and in some places looked like exposures of chalk among the green bushes. The ridges had gently sloping sides, and, being covered by soil, very few opportunities for examining the rocks were presented. In descending the brook, however, the ravine of the pass becomes more narrow, and the stream, by its velocity, has cleared away the earth so that the underlying rock is brought to view. It here loses the peculiar whiteness characteristic of that at the summit, and is more gray, and assumes a structural character, the minerals being arranged in long parallel lines or planes. In some places the rock is syenitic; in others, mica predominates; but, in general, feldspar is the predominant mineral. Considerable quantities of epidote were seen in seams and in coatings upon surfaces of cleavage or divisional planes in the rock. The laminated structure was highly developed in many places, the rock becoming gneissose. Feldspathic veins traversing the rock were also noted. It is very probable that the rocks of the lower parts of the ravine of the pass are metamorphic, while the higher or summit portions are eruptive. I have given the laminated or gneissose portions a distinct coloring on the section. The trend of the rock, nearly three miles below camp, was N. 70° E; and at another place, N. 94° E.; being conformable to the general direction of the main chain. This part of the pass is more rocky than the upper portion, and the granitic and metamorphic rocks rise directly from the brook, so that the trail is confined to its bed.

Sandstone strata.—About six miles from the summit the whole character of the scenery of the pass changes; the hills are lower and more numerous, and present many abrupt and bold escarpments. They are of sandstone and conglomerate, probably Tertiary, and are similar in their appearance to those developed at the base of the Sierra, at the head of the Tulare valley. The outcrops of these sandstones are of great thickness, and they occupy a wide area on the southern flank of the mountains. They are probably the principal formations between the mountains and the Pacific. The planes of stratification are very much bent and folded, and are in many places raised so as to stand nearly on edge. Natural sections made by the brook are very numerous, and beautiful exposures of the edges of the strata, standing at almost all angles with the horizon, are seen on each side. The outcrops do not exceed three to five hundred feet in height above the trail, and it was not possible for me to make any satisfactory estimate of the thickness of the group of beds thus disturbed.

In the rapid observations I was obliged to make I could not connect the numerous flexures which were indicated by reverse dips. The following trends and dips were observed at several distant points:[1]

N. 40° E., dip 70°.
N. 30° E., dip 70°–80°.
N. 10° E., dip 10°.
N. 40° E., dip 70°.
N. 25° E., dip 75° southeasterly.
N. 25° E., dip 65° northwesterly.

The two last observations were made on exposures one-eighth of a mile apart, and an anticlinal axis was indicated.

[1] These results are not corrected for variation.

These strata consist of alternations of conglomerates, sandstone, and shales, in beds of variable thickness and order of succession. The color varies from gray to buff-yellow, and further south to red. The strata are in a semi-consolidated state, and wear away rapidly by the action of the weather. Beds of hard sandstone were, however, seen, and may, perhaps, be found in all of the outcrops. These outcrops of sandstone were found on both sides of the trail for about two miles, and the formation appears to extend northeasterly in a narrow valley between the granite or metamorphic rocks and a ridge of talcose and micaceous slates rising south of them.

The extent of this valley, and its position relatively to the pass, will be seen on the small map of the region, (Map II.) The outcrops are also represented on the general section of the Bernardino Sierra, which extends through this pass.

No intruded rocks in the form of dykes or otherwise were found among these upraised strata, although careful search along the line of exploration was made. As the strata rest immediately upon the adjacent granite, it at first appears that their disturbance and flexed condition was produced by its intrusion. I looked in vain for an exposure of the line of junction between the two formations, neither could I detect any great metamorphism of the sediments, which would probably have resulted if they had been upraised by the inruption of the contiguous granite. It is, therefore, probable that the disturbance was produced by some igneous intrusion at a distance, and not visible along the line of observation. This intrusion may have displaced a portion of the granite together with the strata. Further explorations must determine to what agency these strata owe their present position, whether to a granitic intrusion between them and the Great Basin, or to the inruption of dykes of porphyry, or the approximation of the ridges of granitic and talcose rocks, between which the flexures are the most bold.

Lower down the creek, in the vicinity of the ridge of talcose slates, (see section,) the sandstone formations on the right bank are not so much tilted and bent as higher up in the pass; consequently they do not form such abrupt and precipitous hills. The valleys become more broad, and in some places the strata are nearly horizontal. A large quantity of oxide of iron also enters into their composition, and imparts a red color to some of the beds.

Age of the sandstone strata.—With regard to the age of these strata, I am unable to affirm positively, but am disposed to regard them as Tertiary. Not a single fossil was found in all the outcrops, and therefore there is no such evidence of their age. Their resemblance to the strata at the southern end of the Tulare valley was noted; yet they do not show such a great thickness, nor such thick and firmly consolidated beds.

Ridge of talcose and auriferous slates.—The first distinct outcrop of the talcose and gold-bearing rocks met with south of the Mariposa district is exposed in this pass about nine miles from the summit. At this point the brook issues from among the hills of sandstone, and impinges upon a slate ridge, and afterwards follows the dividing line between it and the sandstones for a long distance.

These slates form a distinct ridge of several hundred feet in elevation above the bed of the cañon, trending nearly due east and west, (magnetic,) and they can be seen to extend in an unbroken ridge for several miles eastward. A narrow valley is thus formed between them and the granite, which is partly occupied by the outcrops of tilted sandstone just described. The dip of the slate is at an angle of 70° northwards, and is very regular and uniform. The rock differs somewhat from those generally described as talcose, found in the auriferous region of the Atlantic States, and also from those seen in Mariposa county. The color is dark gray, passing

into black. The slaty structure is well developed, and the cleavage is facile; smooth, flat surfaces being readily obtained. A fresh cleavage surface presents a silvery lustre, produced by thin films of mica. The composition of the rock, when critically examined, appears to be chiefly quartz and mica; the latter being in exceedingly thin films, and never showing broad plates or cleavable folia. The two minerals are so intimately blended that it is almost impossible to obtain a view of either in an isolated condition. The rock has a strong argillaceous odor when breathed upon, and portions of it appear to have contained minute disseminated grains of sulphuret of iron, which, by its decomposition, has left minute stains of sesquioxyde of iron. Chlorite, or a chrome-green mica, is sparingly distributed in some parts of the rock; especially near quartz veins and seams, which abound in all parts of the ridge.

In a large accumulation of debris, in a cañon leading from the higher part of the ridge, I found many masses in which talc was a principal ingredient, and was closely associated with cellular quartz. They were evidently portions of veins that had contained iron pyrites, and they much resembled specimens from the auriferous slates of North Carolina. The talcose minerals appeared to be the most abundantly developed in the vicinity of, or in contact with, the quartz veins. Similar conditions are found in the Carolinas.

This ridge of slate rock is remarkable for its even bedding or stratification. The planes of bedding are perfectly flat, and without flexures or distortions. The laminæ are as thin as paper, and lie closely together like the leaves of a book; yet the rock is firm and very hard, and thin plates are not very easily separable. The dip, also, is very regular, at about the same angle, even at distant points. This dip, being northerly, is towards the main ridge of granite; the rock, however, does not appear on the opposite side of the valley, adjoining the granite; or if it does, its structure is entirely destroyed by metamorphic action. It is probable that further south, between this slate ridge and the valley of the Santa Clara, there is granitic rock, perhaps eruptive, like that at the summit. This I was not able to verify, as our examination did not extend to the open valley. I afterwards found granitic and highly metamorphosed rocks in the lower portions of the new pass adjoining, and this leads me to the conclusion that these auriferous slates cover the northern flank of a granitic ridge, and dip from it.

Gold.—As the appearance of both the rocks and the quartz veins indicated the presence of gold, I was induced to make several trials of the earth at favorable points in the bed of the creek. Several pans of gravel and black sand, from different places, were washed out, without obtaining the "*color.*" I am informed that there are rich placers not far from the rancho of San Francisquito. These are said to have been worked by Mexicans in 1840, and abandoned in 1849, when the reports of the great discoveries of gold on the Sacramento river were received. The favorable indications for gold in this vicinity are sufficient to warrant a more thorough and extended examination than it was possible for me to give.[1]

It was interesting to observe how completely the direction of the creek was modified by the ridges of slate. The bends of the stream, instead of being rounded curves, make sudden and angular turns around the sharp edges of the strata, and flow in nearly straight lines between these points, conforming to the direction or trend of the rock.

The topographical features and the variations of the scenery, in this pass, change with its

[1] Since the above was written, considerable excitement has been produced by the working of placers in this district, on the Santa Anna river. The accounts have been conflicting and unsatisfactory, but that very considerable deposits of gold exist is proved beyond doubt. A specimen of this gold, which I have recently received, is in fine, irregular grains, intermediate in size between ordinary scale or river gold and that from the "dry diggings." It is of good quality, comparing favorably with the best gold of the Sierra Nevada gold field. August, 1855.

geology. Thus, starting from the summit, the first four miles of descent is between the hard granites that rise in rounded edges on either side, and the valley between them is fertile and well wooded. For the next three miles the granites are more laminated and slaty in their structure ; they offer less resistance to the wearing action of the stream, which has cut a more deep and narrow channel, and commences to descend abruptly, winding about in a series of rapids between rocky and angular points of the granite and metamorphic rocks that rise on each side like walls. Beyond the granite is the belt of sedimentary strata, consisting of sandstones and conglomerates. Here the hills are lower, the valleys more numerous and open, and a view of bold escarpments, formed by the ridges of highly inclined strata, is presented on both sides. Still lower down the pass, the sandstones are not so much disturbed, and the outlines of the hills become more curved ; and near the lower outcrop of the auriferous slates, the surface is gently undulating. The adjoining slates, however, present sharp, angular outlines, cut by abrupt and rugged valleys. They are also covered with trees, while on the sandstones the vegetation is thin and diminutive.

SAN FRANCISQUITO PASS TO THE MOJAVE RIVER.

October 15.—After we had completed the survey of the Pass of San Francisquito, we returned to the narrow, elevated valley of Lake Elizabeth, and turned to rejoin the wagon-train and escort, which were encamped several miles eastward in a valley where grass and water were abundant. The continuation of the sandstone hills, already partly described as extending along the Lake Elizabeth valley, was found on our right for about eight miles. Similar formations appeared to flank the ridge on the left or north of the trail. Opposite the camping place, marked 15th on the map, these sandstones and clay strata were visible on the north, and appeared to separate the valley from the Great Basin, and they were continuous in a series of low hills for several miles beyond. The debris of micaceous slate, somewhat similar to that found in the Pass of San Francisquito, was observed in this vicinity ; and soon after, an outcrop was passed. The rocks have a dark bluish-gray color, and hornblende in long, slender, imperfectly formed crystals is disseminated throughout some portions, in planes parallel with the bedding. Quartz veins were also seen. The bedding of the slates has an inclination towards the north of from 30 to 40 degrees. Two or three miles beyond this outcrop we reached the camp of the main party in the centre of a wet, swampy valley, where the grass and water was abundant. The party having killed a wild cow, fresh meat was abundant, and the camp was afterwards known as the *Cow camp*. It was about thirteen miles southeasterly from the entrance to the Pass of San Francisquito.

The hills immediately south of this camp rise to a very considerable elevation, and are, in fact, the lower ridges of the main chain. They were found to be composed of slaty rocks, similar to those just described. They assume, by almost insensible gradations, a more granite-like structure, and feldspar was abundant in small granular masses, invested with micaceous films, so that the rock, when broken transversely to the lamination, resembled a fine-grained granular porphyry. Quartz veins are abundant in this rock, and are generally in narrow seams, very near together, and preserving parallelism between themselves and the bedding of the rock. Their trend was taken in several places, and found to be N. 70° E., and the dip S. 75°.

The resemblance of these rocks to the slates in the Pass of San Francisquito was so striking that I could not but consider them as connected and of the same formation. There is little

reason to doubt that the outcrops are the prolongation of the metamorphic rocks in the lower parts of the pass. At that place the trend was nearly east and west, and the dip to the north, at an angle of 70°. Here we find, first, a northerly dip of 30° to 40° ; and again, further west, a tread of N. 70° E., with a southerly dip of 75°. The dips are thus reversed, and a great flexure of the beds, with the greatest dip towards the south, is indicated. Lieutenant Williamson ascended to the top of the mountain, and states that the rock is mica-slate, similar to the lower portions I examined.

October 17.—We left the Cow camp, and once more journeyed with the wagons, travelling eastward along the valley. This is bounded by the low sedimentary hills on the north, but soon opens out upon the broad slope of the Great Basin. The sandstone hills disappear in a point; and at this place I was able to make an observation upon the position of the strata, which, before that time, had been so much concealed by their own debris and soil that no satisfactory results could be obtained, although I was disposed to regard them as horizontal. These strata were thickly bedded, and consisted of the debris of granite and pebbles of dark porphyritic rocks. They are not horizontal, but dip northwards, at an angle of 75°. Their trend was N. 85° W. It is probable that this is only a local uplift, and that the hills further west are composed of horizontal strata.

About six miles from the Cow camp we found the commencement of a broad area of low and rounded hills, of sedimentary formations, which are in all probability the extension of the same deposits found throughout the valleys we have been travelling in since leaving Lake Elizabeth and the Pass of San Francisquito. This is also the vicinity of the entrance to a new pass discovered by Lieutenant Williamson during our stay at the last camp. The sedimentary hills rise above the general slope of the Basin, and extend for two or three miles or more opposite the pass, appearing to fill out a bend or depression in the mountains. At the western side of this body of hills, the strata of one of the ridges are distinctly inclined about 25°, and consist of alternations of white, red, and greenish clays. The white consists chiefly of decomposing granitic sand. There are no hard rocks in these hills; all the strata are soft, and can be easily cut through. They are bare of trees, and had a barren, forbidding aspect. They much resembled the tertiary hills of Ocoya creek.

Our course lay around the base of these hills at the north, and thus was out upon the broad slope of the Great Basin. Before passing, however, to a notice of the phenomena observed there, a retrospective glance should be given to the peculiar and fertile character of the strip of country at the base of the north side of the main chain of the Bernardino Sierra. This fertile strip consists of the chain of longitudinal valleys connecting by their ends, formed by outlying low ridges, either of granite or sedimentary hills, at a short distance from the main ridges of the Sierra. Nearly all these valleys, extending over a distance of more than forty miles, or from the center of the Cañada de las Uvas to Williamson's Pass, are adapted to cultivation. Grass grows luxuriantly in most of them, and the soil is deep and rich. There is no lack of water, which, though not found in running streams of any size, is abundantly furnished by springs and ponds. It is very probable that the temperature of these high valleys is low during the winter, and that considerable snow accumulates in them. While we were encamped at different points, ice nearly half an inch thick was several times formed.

About fifteen miles beyond the entrance to Williamson's Pass, we travelled over low hills, composed of sand and gravel and the debris of granite and metamorphic rocks. Descending a narrow valley among these hills, where there was a great quantity of sage bush of unusual size,

we reached Johnson's river, a powerful and rapidly flowing mountain stream, a few yards wide. The water was very pure and cold. The channel or bed of the river was filled with rounded blocks of granite, syenite, and metamorphic rocks, probably all derived from the ridges among which the stream flows. No basaltic or trappean rock was seen. Some of the syenites were, however, very compact and fine-grained. We encamped on the eastern side of the stream; nearly opposite us, there were outcrops of granite, light colored, and decomposing rapidly. It was found to be traversed by great veins of quartz and feldspar. Mr. Ridley, who had travelled among the lower ridges between our last camp and this river, brought me several specimens of agate and carnelian which he had picked up.

Johnson's river to the Mojave, October 18.—A trial was made of the sand along the margin of the stream for gold. Several pans-full were washed out without finding the color. Black sand and garnets were very abundant. The sand and gravel were, however, not taken from the bed-rock; this could not be reached in the short time before starting from camp in the morning. No slate rocks, such as usually bear gold, were seen. Mr. Smith obtained a large peice of white limestone from the top of the hill on the right of camp. This hill and others in the vicinity appeared to be formed of sedimentary rocks in horizontal strata, probably Tertiary.

The route of the Expedition from this river was in a direction a little south of east, over the broad slope of the Great Basin, being below the foot-hills of the mountains, and yet only a few miles distant from them. The slope was broad and gentle, extending for nearly fifteen miles from the mountains without its surface being broken by a ridge or diversified by trees of any magnitude. When looking in advance, the inclination was very evident, and opposite the Cajon Pass there seemed to be a swell of the ground, so that the outline of the descent was brought very distinctly into view; its inclination was approximately obtained by the clinometer, and the angle was found to be between five and seven degrees. Near the mountains the surface was uneven, and furrowed by the channels of streams, then entirely dry; but lower down, all these channels were obliterated, or became so shallow as not to offer any impediment to the passage of the wagons. In the banks of these dry streams the nature of the materials composing the slope was fully exposed, and generally appeared unconsolidated and rudely stratified, in many places much resembling ordinary till or drift.

The higher parts of the slope are covered with a thin growth of the yucca, or Spanish bayonet tree, occupying a belt three or four miles in width. They are interspersed with cedars, which grow to be large shrubs or bushes, and do not form high branching trees. The trunks are, however, quite large—some being over a foot in diameter, and the limbs spread over a wide surface, but the height rarely exceeds twelve or fifteen feet. Sage bushes, (*Artemisias*,) and many small thorny shrubs, grew thickly together in many places between the cedars. Bunch-grass was also common, but was entirely brown and dry.

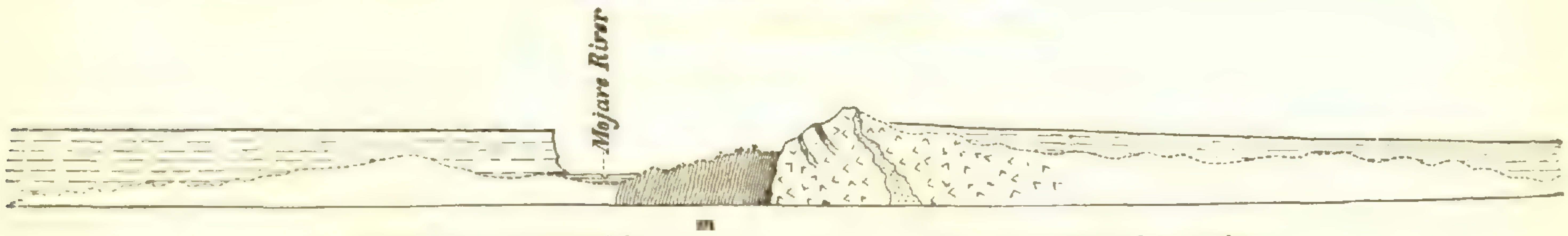
About sunset a small running stream was unexpectedly found. It was not bordered by high banks, nor were there any trees on its borders. It seemed to be a temporary flow from the mountains. After resting at this point until late in the evening, the journey was resumed by moonlight. The air was slightly charged with moisture, and at first the stars were but dimly seen. The course lay, as before, over the unbroken slope parallel with the mountains. The party in advance lighted up their trail at intervals, by piling dry shrubs and bunch-grass against the windward sides of the cedar bushes and igniting them. They produced broad sheets of flame, and made excellent beacon fires. As the day began to dawn in the east, and the outlines of the mountains beyond the Mojave river became visible, we reached the old Spanish trail,

now better known as the Mormon road, leading from the Great Salt Lake to San Bernardino and Los Angeles. No outcrops of rock w re found between Johnson's river and this point. The earth was gravelly, and composed in great part of the debris of granitic rocks. The road was followed over similar soil down to the foot of the slope at the Mojave river, nearly twenty miles from the mountains at the Cajon Pass.

Mojave river, August 20.—The Mojave river at our camp was a shallow stream flowing in a bed of sand, no rocks nor even large gravel being visible. A considerable quantity of black sand was noticed on the dry, rippled surface of the bank, and several pans of the coarsest sand were washed out without finding any gold. I crossed the river to the right bank, and found outcrops of granite and metamorphic rock, and the left bank, a little below the depot camp, appeared to consist of horizontal strata of clay and sand, probably Tertiary.

The granitic or metamorphic rocks rise abruptly from the river, as represented in the annexed section, the tertiary or sedimentary rocks forming a low bluff on the opposite side.

SECTION AT THE CAMP, MOJAVE RIVER.



m. Slaty or metamorphic. *g.* Granite traversed by veins.

Slaty or metamorphic granite traversed by veins.—The outcrop nearest the river had a distinct stratified appearance, and at a short distance looked like vertical strata of roofing slates. The color was black and glistening; a fracture of the rock, however, developed a light-colored interior, and showed it to be a fine-grained syenitic granite. It was found to contain small crystals of light-colored mica and small garnets. It is hard and compact, and the mass has a rhombic cleavage. It owes its slaty appearance to its highly developed structural character, and much resembles a belt of highly laminated, but compact and crystalline, rock observed in the Tejon Pass. These outcrops have a distinct trend of north 5° east, dip 85° west; another observation gave north 8° east, dip vertical.

Beyond this slaty or metamorphosed rock is a granular, gray granite, passing into syenitic granite. This rock forms the great mass of the ridge, and I did not detect any linear arrangement of the minerals. It is traversed by great numbers of feldspathic veins, which show a general parallelism, extending in the same direction as the slaty ridges, and dipping both east and west.

A large part of this ridge is covered by huge blocks and masses of granite, that lie piled one upon another in utter confusion, and are completely impassable. There are no trees or shrubs of any great size. It will be observed from the figure that the slope of the Basin extends high up on the east side of the granite ridge, while it has been completely cut away by the river on the west.

The vegetation along the bottom land of the Mojave is chiefly cottonwood and willows. The grass is, however, good and abundant, and there are probably many places along the stream where the alluvial lands could be successfully cultivated. The presence of large quantities of sand on the low lands near our camp indicated that the river frequently rose to a considerable height, so as to overflow a large surface, and render it unfit for cultivation.

CHAPTER VII.

MOJAVE RIVER, BY WILLIAMSON'S PASS, TO SAN FERNANDO AND LOS ANGELES—LOS ANGELES TO SAN BERNARDINO—CAJON PASS.

MOJAVE TO WILLIAMSON'S PASS.—GRANITE.—JOHNSON'S RIVER.—COPPER ORE.—INCLINED STRATA OF SANDSTONE.—COTTONWOOD CREEK.—ERUPTED ROCKS AND AGATE.—COW CAMP.—ROUNDED HILLS.—BRECCIA OF VOLCANIC ROCKS.—ERUPTED DYKE OF PORPHYRY.—GRANITE AT THE SUMMIT OF WILLIAMSON'S PASS.—TRAP DYKE.—VEIN OF COPPER ORE.—WHITE GRANITE.—SANDSTONES AND CONGLOMERATE UPRAISED.—BLUFF OF SANDSTONE.—GRAPHIC SYENITE.—IRON ORE.—METAMORPHIC ROCKS.—LOW HILLS OF SANDSTONE.—SAN FRANCISQUITO RANCHO.—ALLUVIUM OF THE SANTA CLARA.—SANDSTONE.—SAN FERNANDO PASS.—TERTIARY FOSSILS.—FIG TREES AND PRICKLY PEAR.—SAN FERNANDO VALLEY AND MISSION.—SANDSTONE HILLS, BETWEEN SAN FERNANDO AND LOS ANGELES.—LOS ANGELES.—BITUMEN SPRINGS.—VINEYARDS AND WINE.—SAN GABRIEL.—ROAD TO SAN BERNARDINO.—SAN BERNARDINO.—MORMONS.—SOIL AND CLIMATE OF THE VALLEY.—PRODUCTIONS.—HOT SPRINGS.—ANALYSIS OF THE DEPOSIT FROM THE SPRINGS.—BROOK OF HOT WATER.—SPRING AT THE MOJAVE CAMP.—SOIL CONTAINING SALT.—CAJON PASS.—UPRAISED STRATA OF SANDSTONE, PROBABLY TERTIARY.—GRANITE.—LIMESTONE.—VEGETATION.

After having remained in camp for two days to recruit the fatigued animals, a party was organized by Lieutenant Williamson to survey the new pass that had been found by him; and after traversing it and reaching the valleys of the coast, to proceed along the base of the mountains (Bernardino Sierra) to the Pueblo de los Angeles, thence to the valley of San Bernardino, and through the Cajon Pass back to the Great Basin and the Mojave camp.

The party thus organized consisted of Mr. Isaac W. Smith, C. E., Dr. Heerman, Mr. Koppel, and the writer, together with several men. We took a single wagon to carry the instruments and odometer.

We left the Mojave on the morning of the 21st October, and passed over the slope of the Great Basin towards the mountains, reaching the little stream east of Johnson's river in the afternoon, where we encamped for the night. Distance, 27 miles.

October 22.—Left camp for Johnson's river. Instead of following the party over the slope, by the trail we had before made, I went up to the base of the mountains and skirted them westward. Outcrops of granite were abundant. It was fine-grained, white or light gray, and contained little hornblende. Lines of structure were very distinct, and yet the rock was exceedingly compact and massive. The trend was found at one point to be about N. 10° E., the dip being 90° vertical. The cañons leading from the chain were found to be very steep and rocky. Some large masses of granite were observed that had evidently been transported down the cañons, but they did not extend far from the mouth of the ravines.

We reached the banks of Johnson's river in the afternoon, and camped lower down the stream than the site of our previous camp, but between high banks of the strata of the slope of the Basin, consisting probably partly of drift or detritus overlying Tertiary. The stream at this place was bordered with "sycamore," or the plane tree, and other deciduous trees in great variety, some of them being different from any with which I was familiar; and the water was clear and cold, running rapidly over a bed filled with well rounded pebbles and boulders of syenite and granite, as before observed. A short distance below the point at which we encamped, the river

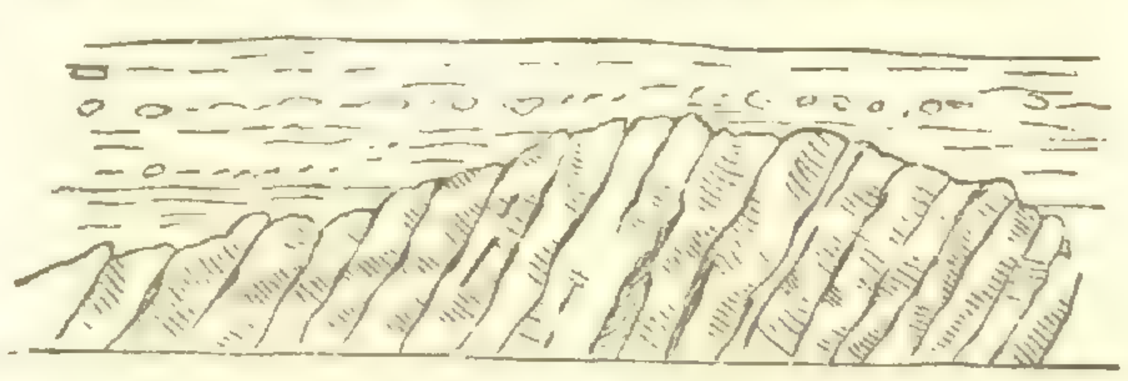
sinks away in the sand, and there is nothing on the broad semi-desert slope to indicate its existence.

We were greatly refreshed by a bath in this beautiful stream, and a night's rest on the clean, hard sand of its borders; and on the morning of the 23d left for the entrance to Williamson's Pass, taking the same trail that had been broken by the wagons of our train a few days previously.

Copper ore.—About seven and a half miles beyond Johnson's river, some small boulders, covered by greenish stains, were observed in a small, dry arroyo, which was apparently formed by the washes during rains. It was soon ascertained that these stains were produced by carbonate of copper, and I concluded to trace these fragments to their source. At the expense of being "late at camp," the parent source was found in an isolated ridge of mica slate and granite about two hundred feet high, and not far from the main ridges of the Sierra. The ore consists of iron and copper pyrites in a quartzose gangue, and has a direction nearly N. 75° E. The upper or outcropping portions are much decomposed, and stained by oxyde of iron and carbonate of copper.[1]

Cottonwood creek—Sandstone strata.—From the copper-ore locality, I passed along the foot-hills, and followed up the dry bed of a stream towards the mountains. It was evident that at certain seasons a very large body of water ran there, as the channel was strewed with large rounded masses of rock, which were mostly of granite, and were piled together in confusion. A grove of cottonwood trees was also visible some distance up the channel, and contrasted strongly with the brown and barren-looking hills on each side. On nearing this grove, indications of water were observed, and several deep pools were found at the base of an almost vertical wall of sandstone strata, which were inclined at a high angle, and surmounted by layers of drift-sand and gravel, as shown in the accompanying figure.

SANDSTONE STRATA OVERLAID BY DRIFT.



It was evident that the water was much higher at certain seasons, and that it flowed with a strong current, it having worn caverns and deep hollows in the strata. These beds consisted principally of the debris of granite, and they were of a light color, with a shade of red. The materials were coarse, and no indications of organic remains were seen.

This stream was afterwards named *Cottonwood creek*, from the abundance of cottonwood near its sources.

Leaving the valley of the creek, I crossed over two, rounded, sedimentary hills, and passed westward to another valley or dry ravine, which was supposed to lead to the new pass. Finding the track of the wagon, which had passed before me, I ascended this valley to the mountains, and rejoined the party. After climbing up steep ridges and cañons in all directions, and not finding a place where the wagon could be taken over, we concluded that we had not ascended the right ravine, and were not at the pass which Lieutenant Williamson had found. We also ascertained by the barometers that we were at an altitude of over four thousand feet, which was much higher than Lieutenant Williamson had represented the summit of the new pass to be, he

[1] For a more particular description of this locality and the ore, see Chapter XX, on metals and ores. Specimens are in the collection Nos. 214, 215, 216.

having taken its elevation approximately by the aneroid barometer. We were obliged to spend the night there without water or grass for the mules. The party during the day had met Lieutenant Parke and Mr. Preuss on their way to the Mojave camp, after having finished a reconnoissance in the vicinity of Tah-ee-chay-pah pass.

Erupted rocks and agates, October 24.—The mistake that we had made, gave me an opportunity to examine the rocks in our vicinity the next morning; they were found to be principally dark colored, erupted, volcanic rocks, containing an immense quantity of the most beautiful agates in pear-shaped masses, and in mammillary coatings upon the fissures and cavities of the rock. The dry beds of the little water-courses were also strewn with the agates that had become detached by the decomposition of the rock. Most of these specimens were milk-white, and were delicately shaded with parallel lines; many were hollow, and the inner surfaces were lined with quartz crystals. These cavities were generally at one side of the specimen; the agate being thickest on the side that was lowest at the time of its formation. The mammillary crusts and coatings along the fissures were of various colors—red, brown, and greenish. Their surfaces were smooth, and possessed a high natural polish.

Where the small rounded masses of agate had fallen out of the rock, they left numerous cavities, that give it a vesicular appearance. A peculiar green crust was very common on some parts of the rock, and at a little distance it looked like carbonate of copper; but it does not contain a trace of that metal.

The position of the locality, with respect to the pass we were seeking, will be seen on the map. I have marked the name Agate creek opposite the stream, as the abundance of this mineral in its bed was its distinguishing characteristic.

We retraced our steps, and, after gaining the broad slope of the basin, travelled to the Cow camp, where there was plenty of grass and water for the refreshment of the fatigued animals. Having found the entrance to the pass, we returned to it the next day and commenced the survey.

WILLIAMSON'S PASS.

The position of this pass, and its direction, will be seen upon the general map and on the geological map of the Tejon and vicinity, Map II, Chapter XV. The pass extends from the Great Basin to the Rancho of San Francisquito, which is in one of the valleys of the Pacific slope. Its entrance on the Great Basin is near the meridian of 118° and latitude 34° 30', and its direction a little south of west; the distance through the mountains from the Great Basin side to the open valley of the Santa Clara river is about 20 miles. The altitude of the summit level is 3,164 feet above the sea.[1]

In the description of the sandstone bordering the lower portions of the Pass of San Francisquito, it is stated that a long valley extends in a nearly northeast direction towards the Great Basin, between the ridge of talcose or chloritic slates and the granite. In travelling at the base of the mountains on the Great Basin slope, between the Pass of San Francisquito and the entrance to Williamson's Pass, outcrops of slate of a similar character were observed along the trail, forming hills on the right, at a point about half-way between the two passes. By inspection of the map, it will be seen that this point is in the line of the northeastern prolongation of the outcrop in the Pass of San Francisquito; and I have therefore concluded that the range is continuous between the two points. This is also the point at which the long valley occupied

[1] See the tables in Lieutenant Williamson's Report.

by sandstone strata reaches nearly to the sedimentary formations of the Great Basin, being separated from them by a narrow, intervening ridge of granite or slates. There is here a geological indication of a good pass, but the crest or ridge of granite was not explored. Williamson's Pass may be considered as formed by a similar and parallel valley on the opposite side of the slate ridge and the granite which adjoins it. The presence of low hills, composed of sedimentary rocks, near the entrance to the pass has already been noted. Our route from the Cow camp to the pass was further south than before; and we travelled among the hills and not around them. They appear to be principally composed of light clays, sand, pebbles, and debris of granitic rocks; all being of a light color, and showing an abundance of pink feldspar. Gypsum, in thin seams, was also found in some of the lower strata.

Breccia of volcanic rocks.—A narrow valley intervenes between the low hills and the volcanic or eruptive rocks, which form the lower ridge of the main Sierra. Before reaching the intrusive rock, I passed thick strata of *breccia*, composed of angular blocks of porphyritic volcanic rocks, of various colors, principally red, brown, and a chocolate color. These blocks were closely impacted, and varied in size from two or three inches to ten and twelve inches in diameter. The strata dip at an angle of 20°, inclining towards the northeast.

Dyke of erupted rock.—The volcanic rock adjoining this breccia forms a considerable ridge, which is crossed by the trail at nearly a right angle. This rock presents a variety of characters and colors. A large portion of it is compact and dark-green, not unlike ordinary trap rock; other parts are porphyritic, being composed of a compact base of a chocolate-brown color, filled with minute white crystals of feldspar. The brown parts of the ridge are also more or less striped, and filled with long, parallel, and thin lines of different shades of colors, giving the mass a ribboned and veined appearance. Various shades of red were also observed in different places; and both the reddish and brown portions are porphyritic. The darker portions of this ridge were nearest to the breccia above described. The surfaces of fissures were more or less covered with a dark-green coating, which appeared like a crust of carbonate of copper, but does not contain a trace of that metal. Some of the fissures also contained imperfect crystallizations of a zeolitic mineral, in radiated and stellar forms—probably stilbite. Agates of various sizes and forms were also seen in the beds of the streams.

It is very possible that this erupted ridge consists of more than one intrusion; the differences found in the rock at different places may be regarded as an indication of it. The ridge, considered as a whole, may be called a compact, fine-grained porphyry. It appears to have a width or thickness of nearly 2,000 feet, and to extend in a southwesterly direction, nearly parallel with the valley of the pass.

The volcanic or eruptive rock, seen on the 22d, further east, at the sources of Agate creek, was, in many respects, similar to this outcrop; if this be regarded as the continuation of the intrusion, a very sudden turn and change of its direction exists, which it is difficult to explain. Further observations are required to determine the exact position, direction, and form of the ridges, which I cannot claim to have faithfully represented on the map, it having been impossible to extend my observations far beyond the line of the survey. It may, perhaps, be found that there are *two* or more erupted dykes.

Granite of the summit.—At the summit of the pass the hills on each side are of granite, which is nearly white and of a fine grain. The mass is compact and tough, and has a sub-crystalline, vitrified appearance, as if it had been partly fused. Some of the surfaces of the broken fragments were observed to be drusy with minute quartz crystals. The valley or gap between the

granite hills at the summit appears to be filled in, to a depth of 100 feet or more, by an accumulation of gravel or detritus of granitic rocks. The same formation skirts the foot of the opposite high hills, extending at their base in a long terrace. This is on the south side of the long southwest and northeast valley of the pass, which is reached from the summit by an abrupt descent of about one hundred feet. The terrace has an even, sloping outline, and is evidently the remnant of a slope that originally extended throughout the valley between the mountains, and filled in between them, in the same way that drift materials of the slope of the Great Basin now fill the valleys and cover the irregularities of the underlying granite and other rocks.

Trap dyke.—A short distance from the summit the valley turns around the base of a hill ot granite. This hill is traversed by a narrow dyke of trap rock of a dark-green color, but it is only slightly exposed in the bank of the stream, and its upper portions are so much covered by debris that I did not ascertain its direction.

Vein of copper ore.—But a short distance from this dyke a vein of copper ore appears on the surface. Its presence is indicated by the green color of the carbonate, and it has been prospected by parties from Los Angeles, who have broken off some of the surface rock, and accumulated several hundred weight of ore.[1]

The general course of this vein was found to be about 45 degrees east of north, and its dip was nearly vertical, or appeared so at the surface. The exposure is about 90 feet above the bed of the stream. The ore is associated with quartz, and may be found in strings and veins over a width of more than fifteen feet.

Before reaching this locality ot copper ore, outcrops of igneous rock were found on the left. A part of the ridge is quite red, and it is over 2,000 feet wide. A small isolated hill on the right appeared to be eruptive rock also.

White granite.—The mountains on the left of this part of the pass are high rugged peaks, composed of light-colored granite, in which hornblende is seldom present. The decomposition of this granite appears to be rapid, and its surface becomes as white as chalk; so that wherever it is visible between the thick growth of dwarf oaks it looks like patches of snow. When a high wind blows over these hills it raises a cloud of white dust, formed by the disintegrating feldspar. The granite seems to be almost wholly formed of white feldspar or albite; and both quartz and mica are in small proportion, and are also very white.

Outcrop of sandstone strata.—A short distance below the copper vein, the upraised and uneven edges of stratified sandstones and conglomerate become visible on the right side of the pass, beyond the low foot-hills of granite. The dark-colored ridge of volcanic rock also shows its summit at several places. These formations appear to extend nearly parallel with the valley, and the intrusive rock comes down to the bed of the stream. Below this the outcrops of upraised strata were nearer to the trail and more distinct, and are seen to be worn into fantastic shapes. A mass of one of the outlying beds on the top of a hill had an outline bearing a close resemblance to the features of a man. This is represented in the annexed engraving from a sketch by Mr. Koppel. It was taken from the camp-ground on the border of the creek in the valley of the pass. The cottonwood trees had been scorched and partly burned by fires.

There was not a good opportunity to examine the lithological character of these strata; but they had the appearance of being nearly identical in their nature with the sediments seen in the

[1] See description of this ore in Chapter XX.

lower parts of the Pass of San Francisquito. The colors presented, were varying shades of gray, red, and brown; the materials were coarse, and, so far as I observed, were not accompanied by beds of shale.

BLUFF OF SANDSTONE, WILLIAMSON'S PASS.

The series attains a great thickness, but it could not be determined with any accuracy. The uplifts and disturbances appear to be produced by the dyke or ridge of intruded porphyritic rock, which extends from the summit nearly half way down to the plains, but appears to be broken in several places. For a part of the way it was hidden from the trail by intervening hills of granite; but there were good evidences of the presence of the rock. The representation of the outcrops on the map is presented as an approximation to their position and relative magnitude. The true direction and extent of the ridges can only be ascertained by a survey for the purpose. It is very probable that several intrusions would be found. A short distance below the end of the ridge of erupted rock, a long valley was seen extending off towards the east, and the dry bed of a stream, very broad, and lined with large boulders, indicated the existence of a powerful current there at some seasons of the year. The rocks thus transported along this creek were mostly granitic and metamorphic, much white granite being found. I picked up several masses, which had a delicate purple or lilac tint, produced by the feldspar. This, however, was a syenite, no mica being visible, but an abundance of hornblende of an olive-green color. The crystals were so disposed throughout the rock that the surface looked as if it had been written upon. The rock in fact is a beautiful *graphic syenite*. The appearance of the surface of one of the pebbles is shown in the annexed figure, the black portions representing the hornblende, and the light the feldspar. The latter is also crystalline, and apparently the cause of the peculiar form of the masses of hornblende. Neither mica nor quartz were observed

in the specimens, but in some, garnets and magnetite were abundant. The size of some of the masses of ore, and the number of the fragments of this peculiar rock, indicated the existence of very considerable quantities up the valley, and we may expect to discover a valuable bed of iron ore in that region.

GRAPHIC SYENITE, WILLIAMSON'S PASS.

The lower part of the pass is narrow, and bounded on each side by ridges of white granite, the sandstone being beyond. About sixteen miles from the summit, the granite hills become higher, and the stream winds in a circuitous course around projecting points of the ridges. Here the granites no longer have the peculiar whiteness, but are highly laminated and micaceous, becoming gneissose, and have the usual dark color. The planes of lamination are bent and contorted, and veins of feldspar and quartz traverse the rock in various directions. These rocks are in all probability metamorphic, and in appearance they present a great contrast to the white and chalk-like granite which forms the hills along a great part of the pass.

Low, rolling hills.—About 19 miles from the summit the granitic hills disappear, and the valley is bounded by low hills of sandstone and conglomerate. The country opens, and a view is pres nted for long distances in various directions. The strata are exposed all along the stream, and dip, at small angles, in different directions; but as we proceeded further from the igneous rocks of the pass, the flexures became more and more gentle, until the strata were nearly horizontal. It will be seen on the map that this part of the pass is not far from the point where sandstone strata were examined in the lower part of the Pass of San Francisquito. They are evidently the same series of sediments, and they form the bounding hills of the valley of the San Francisquito Rancho. The low hills, however, at the borders of the granitic ridges, have a more recent appearance than the uplifted strata higher up in the valley, and they may differ greatly in age. The coincidence of the direction of the pass and of the other principal valleys with the trend of the rocks is worthy of notice, and is well shown on the map. The Pass of San Francisquito, in its upper portion, is an exception to this observation, the valley of the creek being nearly transverse to the trend of the granite it crosses; it is, however, a narrow, rugged cañon in that portion of its course, and it does not compare in extent with the long, low valleys occupied by the sandstones.

We met with considerable difficulty in portions of the pass from the growth of timber and willows along the creek, which filled the whole valley between the ridges on either side and prevented us from progressing, so that we were obliged to cut our way through the thickets and form a road for the wagon; with our small number this was a serious undertaking and occupied much time. On the 26th we cut a road one-fourth of a mile long through the timber, and was obliged to cut again on the 27th and 28th; as we had but one axe, sheath-knives and heavy clubs were brought into use, with which the brush and vines were levelled to the ground. An old pack-trail was found along the sides of the ridges, and was probably formed when the copper locality was prospected.

San Francisquito Rancho, October 28.—After we emerged from the cañon in the granites, and

had progressed for a few miles down the valley in the sandstone formation, we saw droves of cattle feeding at a distance, which probably belonged to the rancho. As soon as we found water in the bed of the creek (which was dry for a long distance in the lower part of the pass) we ncamped and found plenty of good grass for the animals.

The sandstone strata along the bank of the stream were in some places inclined at an angle of nearly twenty degrees, but below camp they were nearly horizontal, and the elevation of the exposure above the stream appeared to diminish towards the lower parts of the valley.

The next day (29th October) we passed over the extensive plain of the rancho nearly to the house on the Santa Clara river. We wound about for several miles among groves of oaks and cotton-wood trees, and saw numerous large herds of cattle attended by *vaqueros*. Cottonwood appeared to be the principal timber, and the evergreen oak (*Q. agrifolia*) was observed on the low hills of the vicinity.

We soon reached the trail that leads from Los Angeles, by San Fernando Mission, to this rancho, and thence by the Pass of San Francisquito to the Great Basin. This is the route taken by the emigration to the Tulare valley and the southern mines along the San Joaquin. When we reached this trail a large drove of cattle was passing, and they were on their way to the Tulare valley through the Great Basin and the Tejon Pass. It required great exertion on the part of the vaqueros in charge of the cattle belonging to the rancho to prevent them from joining the drove and moving off with them. Where there are no fences, as on these great ranchos, it must be exceedingly annoying and expensive to be constantly on the watch in order to prevent the mingling of the herds.

Santa Clara river.—This stream, at the place where the road crosses it, flows in a broad but shallow bed, depressed about twenty feet below the general level of the plain. The vertical banks are seen to consist of horizontal, alluvial strata of sand and clay, very similar in their appearance to those of the banks of the San Joaquin and King's river. This alluvial formation forms a narrow belt along the river, and is so limited in extent that it has not been represented by a separate color on the map.

After crossing this stream, our course was changed at an acute angle towards the southeast, in order to reach the San Fernando Pass. Our road lay for nearly four miles over a level plain, which was intersected in every direction by dusty trails made by the numerous herds of cattle. They presented a curious appearance, extending in nearly straight lines over the broad area. Owing to the absence of a well marked wagon-road, and the confusion caused by these trails, we kept too far west, and, at night, reached low hills of sandstone, and were obliged to encamp without water, except a little that was skimmed from the surface of cattle tracks in a muddy spring near by. While two of the party were engaged in collecting this water, two bears made their appearance in search of their evening drink.

Hills of sandstone.—The sandstone hills at our camp were the foot-hills of a long range that appeared to extend in a nearly east and west direction. The strata were inclined at various angles, the dip at one place being 25°, and at another 30°, towards the north. They were composed of gravel and sand, forming conglomerates, and of compact sandstone. Numerous boulders, of a compact, hard, greenish sandstone, were found in the bed of the stream; and they were, doubtless, derived from the higher hills beyond us. No fossils were observed.

SAN FERNANDO PASS.

October 30.—We moved to the east, and found the trail leading to the pass. A fine brook flows in the foot-hills, and an inviting camping-ground was passed, where we should have rested during the preceding night. Plane trees and the evergreen oaks grew here in abundance, and one of the men found a quantity of small walnuts, similar in every respect, except size, to the ordinary, round English walnut.

The border of this brook was evidently a favorite camping place, and had been much used. Crosses were cut deeply in the trunks of the trees, and some of them were, doubtless, the work of the Fathers many years ago. Among various inscriptions cut in the smooth bark of the large plane trees was one by Joaquin, the much-dreaded bandit and assassin.

This pass is hardly worthy of the name, for it consists of a steep ascent and descent over the range of hills known at the locality as the *Susannah Range.* The ascent from the north is not so abrupt as the descent on the opposite side, which, in some places, becomes nearly vertical, and is not passable for wagons without the aid of ropes. The summit level was found to be less than two thousand feet above the sea, and about six hundred feet above the general level of the plain of the San Francisquito rancho.

Sandstone formation, probably Tertiary.—The only rocks visible in this pass were stratified sands and clays, in some places forming firm, compact strata, and in others appearing soft and crumbling. These strata are unlifted, and their edges are well exposed by deep ravines that have been cut by running water. When these exposed edges were viewed from different points along the trail, they had the appearance of dipping in various directions, and several contradictory results were obtained. It was, however, very plain that the hills had long slopes towards the north or northwest, and that in the opposite direction they presented bold bluffs or escarpments; I therefore concluded that the prevailing dip on the north side of the summit was northward, and that the trend of the flexure was a little north of west and south of east. It is probable, also, that this range is formed by an anticlinal axis of the strata; but the transit was made so hurriedly that it was impossible to give the dips a careful and full examination. The long and gentle slopes towards the north were sparsely wooded with oak trees, but the escarpments were barren, or only covered with tufts of grass, then parched and dry.

After reaching the summit, it was a difficult operation to get the wagon down the hill, for it was so steep that it was almost impossible to descend on foot without passing to and fro in diagonal lines. If it ever becomes necessary to build a railroad at this place, the hills must be tunnelled or cut through. The only rock that will be encountered is the sandstone, and much of it is soft and can be removed by the pickaxe, and it is probable that very little blasting will be necessary.

Fossils.—A short distance beyond the base of this steep hill, I found a boulder of sandstone in the bed of the creek, containing fossils, which were but partly preserved, the greater portion of the lime having been removed, so that neither the shells nor casts were left in a perfect state. The specimens obtained were sent to Mr. Conrad for description, but their specific characters were too indistinct for determination.

They are of the genera *Ostrea, Pecten,* and *Turritella,* and show that the formation is Tertiary.

Late in the evening we encamped under some trees by the side of the creek that flows from the pass, and is one of the tributaries of the *Rio de los Angeles.* The ground appeared to have been cultivated; and in the morning we found that we were under fig trees, and by the side of a

hedge of the gigantic prickly pear, about twelve feet high, and covered with partly-ripened fruit—the *tuna*, or Indian fig. A ladder was resting against the hedge, and the artist has represented the fruit as if collected by hand; a mode of gathering which seems rather incompatible with its thorny nature.

PRICKLY PEAR, NEAR SAN FERNANDO..

The peculiarly moist and balmy air which we experienced at this camp through the night, and the vegetation that indicated settlements and civilization, were delightful to us after travelling so long on the mountains and the elevated and arid surface of the Great Basin.

SAN FERNANDO MISSION.

Soon after leaving our camp under the fig trees, we found that we were entering a widely extended valley with a nearly level surface, without trees or verdure, and bounded on all sides by distant ranges of mountains. On turning the point of a hill, we came suddenly in sight of the Mission buildings, which, with the surrounding gardens, stood isolated in the seemingly desert plain, and produced a most beautiful effect.—(See View VI.) The gardens were enclosed by walls, but the graceful palm rose above them, and groves of olive, lemon, and orange trees could be seen within. Outside of the walls the surface was barren and gravelly, and the fertility within is the result of irrigation.

The building presents an imposing appearance, having a long portico formed by a colonade, with twenty arches, built of brick, or abobe, and plastered and whitewashed. The floor is paved with tiles, and a pleasant promenade in front of the edifice is thus afforded. The remains

MISSION AND PLAIN OF SAN FERNANDO.

of a large fountain, with a circular basin ten feet or more in diameter, was directly in front of the main entrance, and gave an indication of the splendor of the establishment in former days.[1] I was surprised to find the palm growing so far north, (lat. 34° 20′,) and surrounded also by such a variety of tropical fruits.[2]

The grape is cultivated here, and we purchased a quantity of a very pleasant red wine, similar to claret. Several men were employed in filling a large still with the fermented pulp and skins of grapes, from which the juice had been pressed, with the intention of distilling brandy (*agua diente*) from it.

Herds of cattle were seen on parts of the broad plain, feeding on dried grass or the burrs of the California clover, which covers the ground in the latter part of summer when all the grass has disappeared. This plain doubtless presents a beautifully green surface in the winter and early summer when watered by the rains. From the Mission, we passed directly across the plain towards a low range of hills which forms the boundary between it and the plain on which Los Angeles is built. The distance across the plain is about ten miles, and the road was bordered in some places by a low growth of shrubbery and cactaceæ, which gave a peculiar aspect to the country, and reminded some of the party of Mexican landscapes. The distant ranges of mountains had a peculiar barren look, and in color were of various shades of brown, blue, and purple. When we reached the base of the hills, we crossed a running stream, bordered by grass, which we afterwards found to be the Los Angeles river, and then the ascent of the hills immediately commenced.

Range of sandstone hills, between San Fernando and Los Angeles.—This range appeared to extend nearly east and west, bounding the San Fernando plain on the south, and trending parallel with the Susannah range on the north side. Like that range, this seemed formed of sedimentary strata, but they were not so well exposed; and we travelled in such haste that few observations on them were made.

Towards the summit, and near the road-side, I found an outcrop of erupted rock, which was much obscured by decomposition, but showed a globular character, the bank being filled with balls of various sizes, from which successive crusts of the decaying rock were scaling off. It had a dark color, and contained considerable oxyde of iron, indicated by the dark stains. This intrusive rock is represented on the general geological map, but subsequent observations will doubtless add many important facts to the now limited knowledge of the locality.

[1] The Mission of San Fernando was founded September 8, 1797, under the name of *Mission de San Fernando Rey de España*. Upwards of five hundred Indians have been attached to this Mission. In 1838 it could count fourteen thousand cattle, five thousand horses, and seven thousand sheep. Nearly eight thousand fanegas of grain have been harvested and two hundred barrels of wine and brandy in a year.—*De Mofras*, p. 359.

[2] Baron Von Humboldt makes the following observations on the geographical limits of palms: "When we consider the extreme geographical, and consequently, also the climatic limits of palms at spots which are but little elevated above the level of the sea, we find that some forms (the date palm, *Chamærops humilis*, *Ch. palmetto*, and *Areca sapida*, of New Zealand,) advance far within the temperate zone of both hemispheres to districts where the mean annual temperature scarcely reaches from 57° to 60° Fahrenheit. If we form a progressive scale of cultivated plants in accordance with the different degrees of heat they require, and begin with the maximum, we have cacao, indigo, bananas, coffee, cotton, date palms, orange and lemon trees, olives, Spanish chestnuts, and vines. In Europe, date palms, together with a Chamærops humilis grow in the parallels of 43½° and 44°—as, for instance, on the Genoese Rivera del Porrente, near Bordighera, between Monaco aud San Stefano, where there is a palm grove numbering more than four thousand trees; also in Dalmatia, near Sapalatro. It is remarkable that the Chamærops humilis is of frequent occurrence in the neighborhood of Nice and in Sardinia, whilst it is not found in the island of Corsica, lying between the two. In the new continent, the Chamærops palmetto, which is sometimes more than forty feet high, does not advance further north than 34°; a circumstance that may be explained by the inflection of the isothermal lines. In the southern hemisphere, Robert Brown found that palms, of which there are only very few (six or seven) species, advance as far as 34° in New Holland; while Sir Joseph Banks saw an Areca in New Zealand as far as 38°."—*Humboldt's Views of Nature, Bohn's edition.* London, 1850, pp. 297–298.

The roadway over these hills was lined with clumps of the prickly pear, rising to the height of from two to five or ten feet, and bearing fruit which was exceedingly abundant and in full perfection. When perfectly ripe it has a beautiful claret color, with a shade of purple, and is very refreshing to the traveller if suffering from thirst. It is, however, a difficult operation to pick and prepare them for eating without having the hands filled with the sharp prickles. The best way to pick them is to insert a pointed stick at the end, and then cut them loose from the plant with a long knife. They are then securely held by the stick while the skin is cut off.

View of the Pacific ocean.—In descending from the higher parts of the range, the eye was permitted to wander over an extended area sloping gently away from the mountains towards the west. This is one of the most marked peculiarities of the landscape on the western coast; every mountain and mountain range is flanked by long, gently descending slopes, which seem like plains when passing over them, but viewed from a distance their inclination is strikingly evident. In the present instance the slopes appeared to be prolonged in a limitless plain extending to the horizon; but a more favorable point of view showed to us the broad, mirror-like surface of the great ocean.

LOS ANGELES.[1]

Our approach to Los Angeles was over a portion of the slope just described, and we reached the city in the evening of the 31st October. It is on the Los Angeles river, and is about twenty miles distant from the Pacific, where its port, (or *embarcadero*,) San Pedro, is situated on an open bay at the mouth of the San Gabriel and Los Angeles rivers.

Before reaching the city, and about five miles northwest of it, we crossed a small brook with vertical banks, in which the edges of nearly horizontal strata were exposed. They consist of light-colored shales, thinly stratified, and charged with bitumen, which formed black and brown seams between the layers. A coarse conglomerate, composed of sandstone, boulders, and masses of shale, was superimposed on these strata, and looked like ordinary beach-shingle.

Nearer the city, an excavation had been made in the side of a hill into horizontal strata, which were white and chalk-like. They were compact; and large masses of the white rock could be readily broken out, it being very friable and light, yet possessing great tenacity and toughness. This rock is principally siliceous, and does not effervesce with acids. It is underlaid by sandstone, also nearly white. No fossils were found; but the strata are like those afterwards seen at Monterey, and are probably Miocene Tertiary.

Bitumen Springs—"Tar Springs."—There are several places in the vicinity of the city where *bitumen*, or mineral pitch, rises from the ground in large quantities. These places are known as *Tar Springs*, or *Pitch Springs*, and some of them form large ponds or lakes. One of the springs was passed on our way to the city, and was near the outcrop of bituminous shale in the banks of the creek already described. This spring was nothing more than an overflow of the bitumen from a small aperture in the ground, around which it had spread out on all sides, so that it covered a circular space about thirty feet in diameter. The accumulated bitumen had hardened by exposure, and its outer portions were mingled with sand, so that it was not easy to determine its precise limits. It formed a smooth, hard surface like a pavement; but towards the centre it was quite soft and semi-fluid, like melted pitch. The central portion of the overflow was higher than the margin; and it was evident that all the hard, portion had risen in a fluid

[1] The Pueblo de Nuestra Señora la Regna de los Angeles was founded at the end of December, 1781, by order of the governor of California, Don Felipe de Neve.

state, and by the heat of the sun had been gradually spread out over the surface; at the same time, being constantly exposed to dust, it had become so thoroughly incorporated with it that the compound had all the consistency of an artificial mixture. Tufts of "salt grass" were growing in some of the hollows and crevices of the outer portions of the hardened bitumen.

Vineyard and grape culture at Los Angeles.—It is not possible for me to present a faithful and complete representation of the agricultural capabilities and resources of this region—a region which enjoys the advantages of a most genial climate and fertile soil. It is also almost impossible, in this place, even to enumerate the variety of fruits and vegetables that can be abundantly produced here with great ease. The most important production of the soil, at this time, is the grape, which is raised in immense quantities in the suburbs of the town and at adjoining ranchos. It was very delightful, after having been so long in the mountains, far from civilization, and for a part of the time travelling over the arid wastes of the Great Basin, to arrive in this vine-clad valley, and to walk through gardens and vineyards where the purple fruit hung in luxuriant and tempting clusters. Many of these vineyards are very extensive, and are said to contain from 25,000 to 30,000, and even 40,000 vines. Formerly, however, the number of vines was much greater; and I was informed that the vineyard of the mission of San Gabriel, nine miles distant, once contained over 100,000 vines.

These vines are planted about five feet apart, and are not trained on supports or espaliers, but are kept closely trimmed, and are not allowed to spread or to rise over about four feet from the ground. This produces a stout, thick vine, which does not require support. Many of the vines were six and eight inches in diameter. These vines bear enormous bunches of fruit, weighing from one to three pounds and more. Several varieties are cultivated, but all of them are said to have been brought by the Padres from France and Spain.

Since San Francisco became a populous city, the great bulk of the grape crop is sent there for sale. When we arrived at Los Angeles (November 1st) it was the grape season, and the fruit was in full perfection; some of the earlier varieties—the white grape—had, however, disappeared. The vineyards were traversed in all directions by laborers, bearing baskets of the fruit to the packing-sheds, where it was spread out in large piles upon clean white cloths, laid down on the hard ground or upon floors. Boxes of redwood, capable of holding about sixty pounds, are used for their reception, and the clusters are carefully laid in with clean saw-dust.

These grapes could be purchased at the vineyard for three and a half cents per pound, or, if packed in boxes, at $6 per box; they are retailed in San Francisco at from eighteen to twenty-five cents a pound.

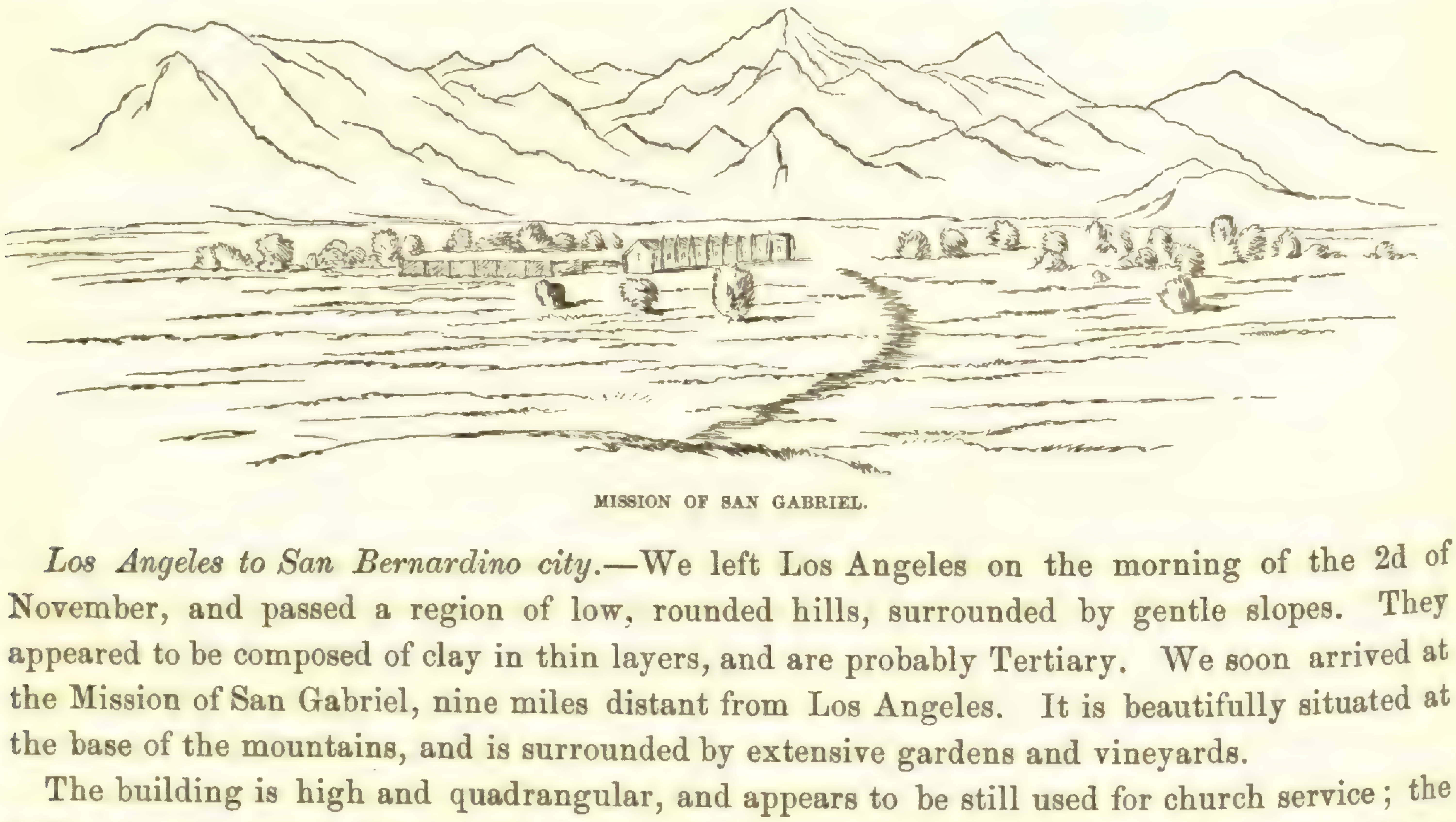
Wine.—Before it became profitable to ship the greater portion of the grape crop to San Francisco, a large quantity of wine was annually manufactured. According to the census returns of 1850,[1] 58,055 gallons of wine were produced in California that year—the greater part of which was from Los Angeles—being about 10,000 gallons more than was made in Ohio for the same year. An old resident of the city, Don Luis, has been prominent among the vine-producers of the State, and his wine cellars were filled with long rows of tierces. This gentleman has one of the largest vineyards in the city, but since 1850 he has made but little wine. Samples of the different wines, both white and red, were obtained; the best white wine being sold for one dollar a bottle, and the red for fifty cents. The second quality of white wine had a slight red color and an agreeable flavor, similar to that of Madeira, but the red wine was not equal to that we purchased at San Fernando.

[1] Compendium United States Census, p. 174.

A cask of the best wine, that was purchased at this vineyard and shipped to New York around Cape Horn, was found, on arrival, to have acquired considerable color, being much darker, and not unlike sherry both in color and taste. A very strong white brandy (*agua diente*) is also manufactured at this vineyard, and is sold for $2 25 per gallon.

I was informed that the quality of the grapes and wine at Los Angeles was not equal to that on several ranchos and at the Mission, which is on higher ground. The vineyards on moist land produce larger and more juicy grapes, but they are not equal in flavor to those grown on dry soils. At some of the vineyards it is not possible to make good red wine, the skin of the berry being deficient in coloring matter. This deficiency is attributed to the influence of nitre in the soil, as it is often seen to effloresce on the surface where a pool of water has dried up.

It is not possible to present in this place a full and fair view of the condition and prospects of the grape culture at Los Angeles and its vicinity; but I became convinced, from the few observations that it was possible to make during our stay of only two days, that the region is peculiarly well adapted to the growth of the grape and other fruits. The genial climate and the character of the soil are favorable, and there is nothing to prevent the multiplication of vineyards to an almost unlimited extent. I believe that when the adaptation of that portion of California to the culture of grape and the manufacture of wine becomes known and appreciated, the State will become celebrated not only for its gold and grain, but for its fruits and wines.



MISSION OF SAN GABRIEL.

Los Angeles to San Bernardino city.—We left Los Angeles on the morning of the 2d of November, and passed a region of low, rounded hills, surrounded by gentle slopes. They appeared to be composed of clay in thin layers, and are probably Tertiary. We soon arrived at the Mission of San Gabriel, nine miles distant from Los Angeles. It is beautifully situated at the base of the mountains, and is surrounded by extensive gardens and vineyards.

The building is high and quadrangular, and appears to be still used for church service; the bells were ringing, and we met numerous parties of native Californians on their way there.

The vineyard appears to be neglected, and is going to decay; the enclosures being broken down and animals having free range through it. Extended and beautiful hedges of the prickly-pear were numerous, and the fruit was very abundant.[1]

[1] The Mission of *San Gabriel Arcángel* was founded by the Padre Junipero Serra, September 8, 1771. This was one of the richest missions of California; and it is said that the number of animals belonging to it at one time was so great that it became necessary to kill the horses in order to preserve sufficient pasture for the cattle. An idea of the extent and resources of this mission establishment will be obtained from the following description, which I translate from the French work of De Mofras.—*Exp. de l'Oregon, &c.*, ii. p. 350.

In 1834, at the time of the opulence of San Gabriel, nearly three thousand Indians were attached to the establishment.

Valley of San Gabriel river.—Monte.—After crossing this stream, we passed over a broad plain which was covered with vegetation, and appeared to possess a fertile soil and to be well suited to agriculture. It was already covered by preëmption claims, and the settlers were busily engaged in erecting small adobe houses, the clay for the adobes being obtained on the spot by digging down a few feet. Many American families were already established there, and we passed several fields of corn and vegetables. The ground is low and moist, and the soil clayey. It is an alluvial deposit.

At the Puenta rancho we tasted some good red wine, like port, manufactured from grapes raised on the place, and beautiful bunches of red and white grapes were obtained at an adjoining house. Large flocks of sheep were feeding upon the burr of the California clover, and the surface in some places was covered with a dense thicket of the dead stalks of the wild mustard, which grows there to a great height. Low foot-hills rose to the northward of this place, but the rocks were not seen. A large portion of the country passed over had an alluvial aspect.

On the 3d of November we stopped at a rancho of a native Californian to purchase barley. I there observed fig and peach trees growing luxuriantly near the house. The rafters of the store-house, from which the barley was taken, were hung with clusters of grapes, which were much dried, like raisins. The land here is well watered, and has a deep clay soil; an exposure along a brook showed an alluvial deposit fifteen feet in thickness. Our movements were much embarrassed this morning by a dense fog, which hung over the landscape until nine o'clock, and prevented us from seeing anything at a distance of over twenty yards. We passed to-day an outcrop of intrusive rock, forming a low ridge on our right, trending approximately east and west. Its position is indicated on the general map as nearly as possible. I also observed low hills of white and yellowish shale, in straight thin layers, not far from the erupted rock.

[On the recent maps of this region from the United States Land Office, a range of hills is laid down, extending nearly northwest and southeast, or from about the point at which the intrusive rock was observed towards the mountains of the Peninsula. This range of hills is probably formed of igneous rocks, dykes of trap, greenstone or porphyry, and uplifted tertiary strata. Geologically, it is probably the equivalent of the San Fernando hills, and those between San Fernando and Los Angeles, and may be regarded as holding a relation to the Bernardino Sierra similar to that of the Coast Mountains to the Sierra Nevada. In the absence of any definite knowledge of this range at the time of writing this Itinerary, the whole slope to the Pacific from the valley of San Bernardino was regarded as nearly unbroken.—1857.]

It possessed one hundred and five thousand cattle, twenty thousand horses, and more than forty thousand sheep. They harvested twenty thousand fanegas of grain, and made five hundred barrels of wine, and as much brandy. At this time (1844) there are not more than five hundred Indians, seven hundred beef cattle, five hundred horses, and three thousand five hundred sheep.

San Gabriel is indebted for the introduction of the culture of the vine to Padre Zalvidea. He made the first attempt upon a vineyard of seventy thousand stocks, and this obtained for him, in that region, the surname of "Father of seventy thousand vines."—(*El padre de las setenta mil cepas.*)

There are fine clumps of palm trees near the Mission, and three grand vineyards, containing nearly two hundred thousand stocks. There are also four superb orchards and kitchen gardens, and an immense garden of olives, and another containing four hundred orange trees. The vineyards, gardens and orchards were surrounded by an impenetrable hedge of prickly-pear, (*figuiérs de Barbarie.*) Padre Zalvidea had negotiated with an American house for the iron necessary to form a fence around the vineyard, and was on the point of having all the materials ready when the secularization took place. This monk distinguished himself by his enterprising spirit. He sent a ship to San Blas every year loaded with oil, hemp and flax. He often sent another to Lima with a cargo of soap and tallow. The number of hides furnished by the Mission was rom twenty to twenty-five thousand a year.

Qui-quai-mungo rancho.—At this place the road from Los Angeles branches, one passing to the Cajon Pass, and the other to the Mormon settlement. The last had been recently laid out and constructed by the Mormons, and led in a straight line over a broad plain, covered with chamisal, to the valley of the Santa Anna, where the city is located. The chamisal is principally *Larrea Mexicana*, and forms a dense growth, which it is almost impossible to break through.

The country between Los Angeles and San Bernardino was passed over very rapidly, and few opportunities for geological examinations were presented. The surface is generally level, and in many places has the appearance of a broad plain. Its sloping character has, however, been mentioned, and a more correct conception of the nature of the region can be obtained by keeping this peculiarity in mind. The mountains, (the Bernardino Sierra,) which are flanked by this extended slope, have a nearly east and west trend, and rise to the height of about 6,000 feet. Near the rancho of Qui-quai-mungo they are called *Qui-quai-mungo mountains*, but this name is not known beyond the locality.

By reference to the map, it will be seen that this slope, or the region between the base of the Bernardino Sierra and the shore of the Pacific, is about 30 miles in width at San Gabriel, and 50 at San Bernardino, while at San Diego it is only about 20 miles. Slopes or plains of this extent are unusual on the western coast, the mountain ranges at other points being flanked by a comparatively narrow slope, or descending abruptly to the ocean. The existence of ridges of intrusive rocks has been noted, and it is probable that others will be found in different parts of the slope, forming low ridges, or ranges of hills. The strata which underlie and form the slope are doubtless Tertiary, and are overlaid by marine drift and beach-shingle, and by the more recent alluvial deposits along the streams.

VALLEY OF SAN BERNARDINO.

The valley of San Bernardino, which has been selected by the Mormons as the site for their new city (San Bernardino) in California, is connected with the series of beautiful valleys and slopes just described. It is situated at the southern base of the high, and during the greater part of the year snow-capped, peak of San Bernardino, and is irrigated by the waters that condense on its summit and flow in many channels down its sides. The northern boundary of the valley is formed partly by this mountain, and partly by the adjoining ridges of the mountain chain that trends westward, and has already been described as the Bernardino Sierra. At the peak of San Bernardino the trends of the mountains change, and become more southerly in direction, and these form the eastern boundary of the valley. Through these bounding ranges of mountains there are two passes which communicate with the valley, one leading northward up to the surface of the Great Basin, called the Cajon Pass, and the other leading eastward over the mountains south of San Bernardino, called the San Gorgoño or San Bernardino Pass.

The principal stream of the valley is the Rio Santa Anna, which is formed by the union of several streams that rise in the mountains at distant points between the Cajon Pass and San Bernardino Pass, and have their point of junction at the city. These numerous streams wind about, and thus form a wide area of bottom-land which is peculiarly rich and well adapted to agriculture. The valley may, in fact, be considered as a broad and shallow excavation, formed by the action of the streams upon the slopes that formerly flanked San Bernardino and the adjacent mountains, these slopes having been a continuation of those that now remain in detached portions between the mountains and the Pacific.

The road which leads from Los Angeles to San Bernardino passes over one of these remnants of the former slope, and, on approaching the valley of the Santa Anna, it becomes evident that the bottom-land was formed by the action of the streams, and the traveller descends abruptly from the plain upon which he has been travelling to the level of the river banks below. The valley is thus partially bordered by a terrace or bank formed by the edge of the slope. One of the streams flows at the foot of this terrace, and at the point where the road descends it is bordered by a growth of plane trees and grape-vines. Boys were seen fishing for trout in its clear waters. A saw mill, for sawing pickets for fences, is located near that point, and from there to the city, near the centre of the valley, the indications of a thriving and industrious community were everywhere evident.

The Mormons arrived in this valley from the Great Salt Lake in the fall of 1851, and having but little time to prepare for winter, their houses were rudely constructed of logs and adobes and have not yet been rebuilt. The city consists of an open square, surrounded by log houses and stout pickets, they having been obliged to bring their dwellings together in this way in order to be secure from the attacks of the Indians. They are now, however, erecting neat adobe buildings in all parts of the valley, and bringing it under cultivation. Messrs. Lyman and Rich, the prominent men of the settlement, have erected a convenient store and post office in the centre of the square, and we were enabled to procure a fresh stock of provisions—flour, fish, butter, &c.—for the party. A large flour mill, twenty-five feet by forty, with two sets of burr stones and a race-way one mile in length, had just been completed : a storehouse of adobes, thirty feet by seventy, was nearly full of sacks of grain waiting to be ground. A large quantity of good flour is made here and is sent to market at Los Angeles or to San Pedro for shipment.

Soil and Climate of the Valley.—A great variety of soils is presented in the different parts of the valley, at different distances from the streams and at different elevations above them. They are, in general, very fertile and adapted to cultivation, and to the growth of all kinds of grain and fruits. In many places, the peculiarities of surface and soil are the same as in the Great Basin, on the opposite side of the Sierra ; but a great contrast is presented in the aspect of the landscape. The valley is decked with vineyards and cultivated fields ; while on the Great Basin side, yucca trees and thorny shrubs cover the dry and desert-like surface. The great difference in the altitude of the two places is, also, strikingly apparent, when an observer stands in the valley and looks upwards to the hoary summit of Bernardino and the high peaks about the Cajon pass, and it is remembered that when standing on the plains and slopes of the Great Basin, near the top of the mountains, these peaks appear as comparatively low hills.

The soil is principally derived from the disintegration of granite. On the higher parts of the valley, or on the terrace or slope above the bed of the Santa Anna, and in some places below the upper plains, it is rather coarse and gravelly, and not unlike the granitic soils of the San Joaquin plains and the Tejon ; it would, however, be exceedingly fertile if well watered. Along the river bottoms the soil is very much finer, and contains more clay. The Santa Anna flows in a shallow, sandy bed, but little depressed below the general surface or bottom. The portions of this bottom-land nearest the river are somewhat sandy ; but in other places the soil is a rich, deep loam.

A specimen of both the upper soil and the subsoil was taken near the settlement, and not far from a pit where adobes were being manufactured.—(See Nos. 265 and 266 of the catalogue and collection.) An examination shows that the soil is a sandy loam containing seventy per cent.

of sand, consisting of angular grains of quartz, much yellow mica, fragments of a dark colored rock, occasional grains of feldspar and a notable quantity of magnetic iron. The organic matter amounts to 3.16 per cent. The presence of the following substances was ascertained by qualitative analysis :[1]

Silica.
Alumina and oxides of iron and manganese.
Lime.
Magnesia, (little.)
Soda.
Potash, (traces.)
Chlorine, (abundant.)
Sulpuric acid.
Phosphoric acid.

The soil thus appears to have all the elements required for great fertility. Its color is a dark brown. The subsoil has, also, been examined, and found to be very similar to the other. It contains 75.5 of sand, very much like the first, except that small calcareous grains are found, which effervesce strongly with dilute acids. The following substances are present :

Silica.
Carbonate of lime, (1.09 per cent.)
Magnesia, (a little)
Sulphuric acid.
Phosphoric acid.
Chloride of sodium, (abundant.)
Potash.

In many places along the river bottom, especially on the low ground, the soil is highly charged with salts, which effloresce on the surface, and form white crusts, preventing the growth of useful grasses. A specimen of the incrustation, (No. 259,) on being subjected to chemical examination, was found to consist of:

Chloride of sodium.
Sulphate of soda.
Carbonate of soda.
Sulphate of magnesia, (trace.)

On the low land, near the town and the mill, the efflorescences were partly dissolved in shallow pools of water, coloring them, in conjunction with the organic matter, to a rich dark brown, very similar to the drainings of cattle yards. Some of the incrustations appeared to contain nitre or nitrate of soda. The luxuriance of the crops of wheat that have been raised at this place have borne sufficient testimony to the richness of the soil. The straw grows so thick and heavy, that much of it falls down, and it is said to be frequently over seven feet long. Two good crops may be raised from only one sowing. The climate is delightful, and is well adapted to the growth and ripening of grains and fruits. The rains commence early in November, and continue at intervals through the winter. The surface becomes beautifully green in December, and the only severe season for cattle is in the fall, when the upland grasses are completely dry and dead ; but they can then resort to the banks of the streams, which are green throughout the year. Wheat and barley are sown in November and December, and vegetables may be planted at any time through the winter. Cabbages, beets, &c., grow on continuously, without regard to seasons. Potatoes are planted in November, and sweet potatoes have been found to grow well in some of the sandy parts of the valley. The greatest amount of butter is made in the months of January, February, and March.

[1] See Appendix.

This is a favorable place for the culture of the grape, and for many of the tropical fruits; it will, doubtless, soon become noted for the excellence and variety of its productions. The cold summit of the peak of San Bernardino, upon which snow rests for the greater part of the year, has a great influence on the climate of the valley, and moderates its temperature during the night by the cool currents of air which descend from it.

In the Bernardino Sierra, especially in the cañons and ravines near the summit, and between the Cajon Pass and the peak of San Bernardino, there is abundance of pine and spruce timber, which was being cut and sawed into lumber by the Mormons for their own use, and for sale at Los Angeles. The brooks which flow through the ravines furnish good water-power, and several saw mills have been erected high up in the mountains. These supply San Bernardino with lumber, and furnish a large surplus, which is carried to Los Angeles for sale. A good road has been made from these mills to the settlement at great expense, and a large quantity of lumber is brought down and taken to market. When the railroad is constructed from the mouth of the Gila to this valley, and beyond it to Los Angeles, a large part of the timber for ties can be obtained from these forests, cheaper than it can be procured from Oregon.

Hot springs.—Around the borders of the valley there are numerous localities of thermal springs. The warm and hot waters gush out from the granitic rocks on the flanks of San Bernardino and the adjacent heights. In one place the springs are so numerous, and the water rises in such volume, that a good sized mill-stream of hot water is formed, which flows down into the valley and is one of the principal tributaries of the Santa Anna river. This brook of hot water retains a temperature of 100° three or four miles from its source.

I visited several of the springs on the side of the Sierra, between San Bernardino mountain and the Cajon Pass, near the saw mill road, and found them to rise through an accumulation of drift and debris, along the banks of a small mountain brook. It was evident that the subjacent granite was very near the surface, as shown by one or two outcrops, from one of which the hot water issued. Small springs rise at intervals of ten to twenty feet, along a distance of thirty or forty rods. Their waters unite and form a little stream that empties into the brook, a short distance below. The banks of these streams were thickly overgrown with grass. A dense mass of beautiful green confervæ grew from the bottom and sides of the channel, and floated in rich, waving masses in the hot water. In the immediate vicinity of the springs, however, no vegetable growth was visible. The rocks and gravel, in contact with the water, were covered with a snow-white incrustation; and little twigs and leaves that had fallen into it were softened to a white pulpy mass, and were partly incrusted. This was also the case with insects that were lying dead in the shallows of one of the springs; but I could not observe that, in either case, any petrifaction or internal deposition of mineral matter had taken place.

The following temperatures of different springs were observed: 172°, 169°, 166°, 130°, 128°, 108° Fahrenheit. The temperature of the hot stream, below all the springs, was found to be 130°, and the mountain brook only 65°. Temperature of the air, 76°.

The variation in the temperature of the springs is undoubtedly caused by the different circumstances under which the water reaches the surface. Some of them boil up among a mass of granite boulders and gravel, and others run out from the side of a bank of loose detritus or drift overlying the granite.

The white crust was not found in equal quantities at all of the springs. It appeared to be most abundant at one of them. It adhered very closely to the rocks, and formed little projecting points or blunt protuberances from their surfaces. Some of the pebbles lying in the stream

were thickly coated upon the upper side, and were placed in the collection, (No. 253.) An analysis of the crust, since the return of the Expedition, gave the following results:

"The aqueous extract contained only a small quantity of chloride of sodium, (salt.) In hot hydrochloric acid, the mass dissolved with strong effervescence, leaving a residue of silica and alumina. The solution contained:

Lime, (carbonate,) chief constituent.
Silica (soluble in acid.)
Magnesia.
Alumina and oxide of iron, traces.
Phosphoric acid, trace.

A distinct reaction for fluorine was obtained by heating the powdered mineral with fragments of marble and concentrated sulphuric acid in a dry flask; passing the gas through aqua ammonia, evaporating this solution to dryness, re-dissolving, filtering and testing this filtrate evaporated to dryness by etching."[1]

It thus appears that the principal constituent is carbonate of lime, and that soluble silica is also present. It is desirable that more examinations should be made of these incrustations, and a quantitative analysis is very desirable.

The springs were estimated to be at least five hundred feet above the level of the Santa Anna, at the Mormon settlement, and thus nearly 1,618 feet above the sea.

These springs are not the sources of the large stream of hot water first referred to. It takes its rise further eastward, nearer the mountain of San Bernardino. I regret that I could not visit its source, as the springs must be numerous, and of great volume and high temperature, to send forth such a large stream of water, retaining its temperature a long distance from the mountains.

I was informed that there are several other localities of hot springs along these mountains; and there are, no doubt, many that have not yet been discovered.

The water of some of these springs contains alkalies and salts in solution. This was clearly shown by sticks or weeds that were partly immersed in the water, producing favorable conditions for continuous evaporation from the outer ends. These were thickly covered with salts in semi-crystalline crusts; they dissolved readily in the mouth, giving a cooling sensation, similar to that produced by nitrates. The waters are supposed to possess medicinal virtues, and the Indians have been accustomed to resort to them for the cure of diseases.

The large stream of hot water appears to be nearly pure, and is not disagreeable to the taste. It is used for drinking and cooking at the settlement several miles below. A bathing establishment on a grand scale could easily be erected on the banks of this stream. I enjoyed a delightful bath in it, the desired temperature being easily obtained by ascending or descending the stream. The granite at the springs contains a large proportion of flesh-colored feldspar, distributed in veins. It appears to be much cracked and fissured; but this may be due to atmospheric decomposition alone. The rock around the springs is sensibly warm to the hand, at a distance of four feet or more from the orifices. There are no indications of erupted trappean or volcanic rocks in that vicinity; nor is it at all probable that San Bernardino is volcanic. It has the appearance of granite.

I left San Bernardino on the 6th November for the Cajon Pass, intending to join Mr. Smith, who was surveying it. The ascent to the entrance of the Cajon was very gradual, and there was no sudden rise of the ground. My road lay over broad fields where large crops of wheat

[1] This analysis was made at my request by Dr. J. D. Easter, of Washington, D. C.—See Appendix, Article VII.

and barley had been harvested, and I reached the cañon about dark. I travelled onwards in the dark, keeping the trail as well as possible, until late in the night, when the noise of mules was heard, and soon afterwards the teamsters' camp was found. Mr. Smith had camped beyond. My mule was soon picketed, and rolling myself in a blanket I slept until daylight.

November 7.—In the morning everything was enveloped in a thick fog, so dense that objects could not be seen at a distance of twenty or thirty feet. The amount of water precipitated on the trees and shrubbery was enormous, although it did not rain. The elevation of this part of the pass is over 3,000 feet. As the wind arose, the fog rolled upwards towards the summit and permitted the surrounding ridges to be seen. Reached the depot camp, on the Mojave, in the afternoon. The water at the spring is much warmer than the air; its temperature was found to be 73°, and the air 60° F.

November 8.—At daylight this morning the ground was covered by frost. Temperature of the air 34°, water of the spring 72°. Diameter of the basin of the spring about twenty feet; depth one foot to eighteen inches; sandy bottom. The soil at camp was very light and dusty and looked like dry ashes. It was composed chiefly of clay and sand. In some places there was a thick growth of "salt-grass" and efflorescenses of salt were seen. A sample of this soil was taken, (No. 264 of the collection.) On examination it was found to effervesce strongly with dilute acid; the aqueous extract contained—

Chloride of Sodium.
Carbonate of Soda.
Sulphate of Soda.
Sulphate of Magnesia, (little.)

At the breaking up of the depot camp, and the division of the party, I acccompanied Lieutenant Parke with the train of wagons to the Cajon Pass and through it to San Bernardino.

CAJON PASS.

This pass has been known and much used for many years, being the point where the old Spanish trail from New Mexico to California reaches the settlements of the coast. It has been called *El Cajon de los Mejicanos,* but is now well known simply as the *Cajon.*

It leads from the valley of the Santa Anna, over the Bernardino mountains, to the surface of the Great Basin, near the sources of the Mojave river. It crosses the Sierra at one of its lowest points in that vicinity, but its summit is more elevated than either of the other passes through this chain, being 4,676 feet above tide, while Williamson's Pass is 3,164 and the Pass of San Francisquito 3,445.

This pass presents one great peculiarity—the surface of the Great Basin forms its summit-level—and the traveller, when approaching the pass over the slope of the Basin, which is so gentle as to seem like a level plain, finds himself at the summit-level of the pass, without having encountered a single ridge. This peculiar configuration of the surface is well shown by the profile of the pass and is considered at greater length in the chapter devoted to the description of the Great Basin. The following observations on the geology of the pass were made in succession from the summit or margin of the Great Basin downwards towards the valley of San Bernardino.

By reference to the Geological Map, the relative position of this pass to others and a general view of its geology may be at once obtained. The high ridges which bound it on each side are granitic, and at the margin of the Great Basin they separate, so that a re-entering angle is

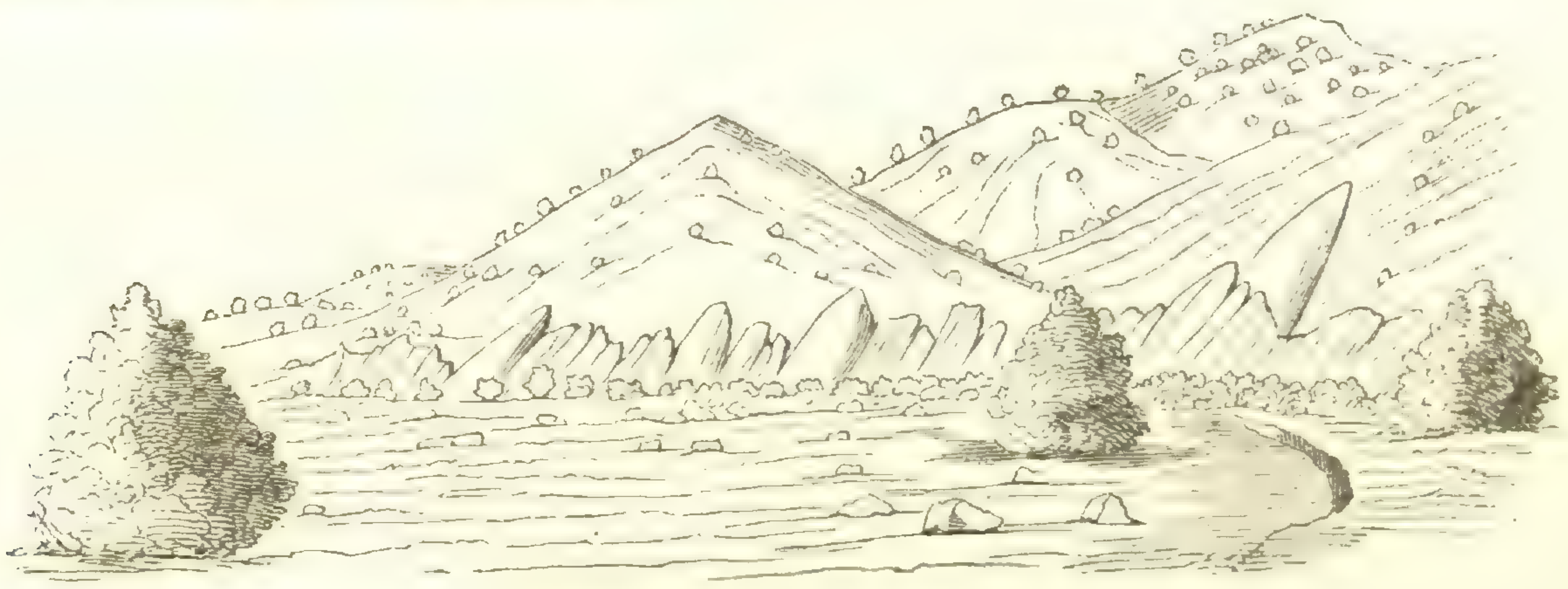
formed ; the space thus partly enclosed is occupied by sedimentary formations. At the summit-level, the sediments which constitute the slope of the Great Basin form an almost vertical bluff, facing the south, and about 500 feet in height. It is necessary to descend this deep declivity in order to reach the valley of the little creek (Cajon creek) that flows to the valley of San Bernardino. The descent of the pass is thus commenced at the very margin of the slope of the Basin, and there is no exposure of granitic rocks at the divide. The materials which compose this formation are rudely stratified, and many irregular beds of coarse gravel and granitic debris were noted. The lines of stratification, as seen in the face of the bluff, were nearly horizontal; but this exposure is believed to be at right angles to the direction of the dip, and therefore does not give a correct view of the position of the strata. They probably dip northwards, or away from the granitic elevations, at a very slight angle; no greater than their original position as deposited, and probably conforming very nearly to the present inclination of the slope. In their general appearance, the strata were like those seen at various places around the inner slope of the Bernardino Sierra, and they appear to consist, almost wholly, of the debris of granite, and to have been derived from the degradation of the surrounding heights, under the influence of currents or strongly agitated waters.

Accumulations of this description have generally been termed *drift* or *detritus* in this report—these terms having been used in their most general sense, and without reference to the age of the formations.

UPLIFTED SANDSTONE, CAJON PASS.

Upraised sandstone strata.—A short distance below the bluff at the summit there are numerous low hills of regularly stratified sandstone. These strata are not horizontal, but are highly

inclined. About one mile from the summit, the disturbance is very great, and the strata rise in a series of nearly vertical beds, forming precipitous ledges of bare sandstone, which have become fantastically worn and moulded by weathering. All the angles and edges of the beds are rounded off, and a series of hollows and cavities has been produced along the junction of the strata differing in hardness. Sufficient soil has accumulated in these cavities to support a growth of small vines and shrubs, that form belts of verdure on the barren bluffs. The appearance of some of these hills is well shown in the preceding sketch, taken from a point in the valley of the creek, which at that time was quite dry.



POINTED OUTCROPS OF SANDSTONE.

At another point not far distant from that represented in the sketch, and much nearer the granite, the strata rise up in a succession of sharp pinnacles—produced by weathering—and are inclined away from the granite. The prevailing dip of the strata is about 45°, and they do not present any appearance of metamorphism by heat or great pressure. They have a modern look, and their barren and singular surfaces present a strange contrast with the green shrubs that cover the slope of the adjoining granite. This formation is unlike that which forms the bluff at the summit, being more even in texture, harder, and apparently uncomformable in stratification. The strata are, however, of a light color, and are not very firmly consolidated, but in many places are soft and friable, and have a light reddish or pink color, which may be caused by the large amount of pink feldspar that they contain. The beds seem chiefly composed of sand and angular gravel, derived from the attrition and wearing of granite and the allied rocks. Some of the beds are compact sandstone, very uniform in texture, and others are conglomerates, frequently containing large rounded boulders of granite and other rocks. It will be seen that, lithologically, they resemble the strata of the summit, and at first I was inclined to consider them as one formation, but the tilted strata are undoubtedly older than the recent or drift deposits of the slope, and underlie them; but where the strata are not disturbed, it would be difficult to distinguish between the two. The sandstones vary but little in composition; there are no shales or other strata that simulate the sandstones of the vicinity of San Francisco and Benicia; their color and appearance are entirely different. I searched in vain for any fossils. I also looked for outcrops of intrusive volcanic rocks, to which the present highly tilted condition of the strata could be referred, but was unsuccessful.

The granite appears to have been disturbing rock, but no indications of a local intrusion were seen. The ridges were, however, examined only at their bases, it being impossible to carry the observations far beyond the trail. The whole bulk of the sandstone formation is insignificant when compared with the adjoining granite ridges, which rise from one to three thousand feet above the outcrops of the strata. It is highly probable that this formation is Tertiary, and that it corresponds with the sandstone of Williamson's Pass and the Pass of San Francisquito;

but, as yet, there is no evidence of this, other than mineral composition and appearance. A further examination is highly desirable.

Granite.—Outcrops of sandstone, similar to those described, are found along the trail for seven or eight miles below the summit. The valley then grows more narrow, and the stream cañons in granite rocks, which rise in high mountains on each side. These granites are both compact and gneissose, and are associated with the talcose slates, traversed by quartz veins, similar to those occurring at the Pass of San Francisquito. Erupted trappean rock was observed in connexion with these formations. This part of the valley was passed in the night, and it was therefore impossible to make detailed observations on the varieties and peculiarities of the granitic rocks.

In the upper part of the pass, nearest to the Great Basin, the dry bed of the stream, that flows in considerable volume in the rainy season, is strewed with boulders of white limestone, veined with blue; these indicate the existence of a parent mass in the vicinity.

Slope of drift.—On approaching the valley of San Bernardino a bank of loose drift-soil and rocks is seen along the base of the mountain on the left. This is a remnant of the former slope that stretched from one side of the valley to the other, and was connected with those bounding the Santa Anna river on the west. It has gradually been moved by the excavating power of the stream, and the material has been carried down to form a new slope below, now a portion of the valley of San Bernardino. Abundance of good stone for purposes of construction can be obtained in the central portions of the pass. The principal timber along the road is plane tree and oak, but pine can be procured from the high, sheltered cañons. Near the summit, various interesting shrubs were seen; the *mancinita*, with its brilliant red bark, being conspicuous. The wild plum was also abundant, and a species of aloe (*maguey*) was occasionally found. A beautiful oak with enormously large acorns, similar to those seen in the Tejon Pass, grows by the road side, and was loaded with fruit.[1] Many of the plants which seemed to be peculiar to the Great Basin were seen in this pass, and contrasted with the vegetation common to the Pacific slope. This distribution has probably resulted from the fact that there is no crest or elevated ridge to separate the Basin from the waters of the creek, and many of the shrubs or their seeds may have been floated down by the stream.

This pass and the old Spanish trail is now principally used by the Mormons and other emigrants from the Salt Lake to Southern California. It was through this pass that great numbers of horses and cattle were formerly driven out into the Great Basin by bands of Pai-Ute Indians, who entered the valley by night and were safely back again through the pass with their spoils before morning. It is said that another pass, nearly parallel with this, but much more rugged and steep, is found about three miles to the westward, and is called "*El Cajon de los Negros.*"

[1] Drawings of the leaves and fruit of this oak, and specimens of each, have been submitted to Dr. Torrey. He has determined it to be a new species, and named it *Quercus crassipocula*.

CHAPTER VIII.

SAN BERNARDINO TO THE COLORADO DESERT—COLORADO DESERT TO CARRIZO CREEK AND WARNER'S VALLEY.

SAN BERNARDINO OR SAN GORGOÑO PASS.—SALT ON THE BORDERS OF THE SANTA ANNA.—WEAVER'S RANCHO.—SUMMIT.—SAN GORGOÑO MOUNTAIN.—GRANITIC AND METAMORPHIC ROCKS.—ROCKS CUT BY DRIVING SAND.—PREVAILING WIND.—METAMORPHIC ROCKS.—SECTION.—ABSENCE OF VEGETATION.—LIMESTONE.—HOT SPRING.—PALM TREE.—CACTACEÆ.—DRIFTING SAND.—BARLEY FIELD.—DEEP WELL.—SAND HILLS.—BLUE CLAY FORMING A HARD SURFACE.—WATER-LINE ON THE ROCKS.—CALCAREOUS INCRUSTATION.—EVIDENCES OF AN ANCIENT LAKE.—SMALL SHELLS OF FRESH-WATER SPECIES.—COHUILLA INDIANS.—VILLAGES AND SPRINGS.—TRADITION OF A GREAT SHEET OF WATER COVERING THE VALLEY.—SALINE INCRUSTATIONS.—SOIL OF THE VICINITY.—SPRINGS.—WATER-LINE, ITS ELEVATION.—THICK CALCAREOUS INCRUSTATION.—VIEW OF THE EXPANSE OF THE DESERT.—CLEARNESS OF THE AIR.—SHADOWS OF THE MOUNTAINS.—SLOPE BORDERING THE MOUNTAINS.—BOTTOM OF THE ANCIENT LAKE.—RAVINES IN THE CLAY.—OUTCROPS OF STRATA HOLDING CONCRETIONS.—CONCRETIONS.—MIRAGE.—SALT CREEK.—SHELLS.—SILICIFIED WOOD.—SAND DRIFTS.—DRIFT OF VOLCANIC ROCKS.—HORIZONTAL STRATA OF CARRIZO CREEK.—AGAVE.—PALM SPRINGS.—VALLECITO.—GNEISS AND MICA SLATE.—VEGETATION.—SAN FELIPE.—INDIANS.—RAIN.—WARNER'S PASS.—OAK TREES AND GRASS.—WARM SPRINGS.—GRANITE.

November 12.—We left our camp near the mill in the valley of San Bernardino, and, crossing the Santa Anna river, proceeded eastward towards a wide pass in the mountains, which had not been explored. The river bottom of the Santa Anna was very broad at this point, and much of the surface was covered with "salt grass," and in some places the earth was impregnated with salts, which formed thick crusts or coatings. The bed of the river is sandy, and a considerable deposit of sand is found along the stream on both banks. We soon reached the ruins of the old church, or rancho, located on slightly elevated ground, and overlooking the whole valley towards the east.[1] It is surrounded by a broad area of excellent farming land, and a row of old trees, set thickly together, extends in a straight line for three-quarters of a mile or more along the bank of an *ascequia*. The building is made of adobes, but is now in ruins; a part of it, however, is occupied as a farm-house and a granary.

After procuring several thousand pounds of barley, we again travelled eastward. The ground from this point was gently ascending, and a part of the time we travelled along the bed of a small brook. We encamped in a wide grassy valley, without trees, within sight of a solitary house on a slight eminence, known as "Young Weaver's."

SAN BERNARDINO OR SAN GORGOÑO PASS.

The Pass of San Bernardino[2] is about twenty-five miles east of the Mormon settlement of San Bernardino, and leads from that beautiful valley into the valley of the Colorado desert. By reference to the map, it will be seen that it crosses the mountains just south of San Bernardino mountain, at the angle formed by the meeting of the Bernardino Sierra with another chain which extends off towards the south, and forms the peninsula of Lower California, terminating

[1] This rancho belonged to the Mission of San Gabriel, and a church was erected upon it.—*De Mofras* ii, 351.

[2] I use the name *San Bernardino* in these descriptions in preference to *San Gorgoño*, because the pass is at the base of San Bernardino mountain, and leads into the valley of San Bernardino. The name thus serves to indicate its locality.

at Cape St. Lucas. The following descriptions are accompanied by a geological section, which will serve to give a general view of the geology. The profile is taken from the barometrical observations of the Survey. The outline and summit of Bernardino mountain is sketched in with its estimated elevation of about 9,000 feet. This mountain is on the north side of the Pass, and San Gorgoño mountain on the south.

November 13.—Leaving the camp near the house of Mr. Weaver, jr., we ascended the valley of a stream which has cut its way downwards below the general level of the slope. High banks of sedimentary accumulations bounded our way on the right and on the left. These are unconsolidated, and appear very recent, simulating those of the slopes of the Great Basin. No regularly stratified and firm sandstone was seen; the materials seemed to be irregularly stratified and generally coarse. They were not, however, closely inspected, the favorable exposures being at a distance from the trail. The ascent continued very gradual; at length a short hill brought us to the edge of a broad and gently sloping plain, upon which an adobe house is built. This, although partly in ruins, was occupied by Mr. Weaver, well known as an experienced mountaineer. He is the claimant of a large rancho at this place. The presence of fruit trees and other evidences of cultivation showed that the rancho had been in use for many years, and it is said that the occupants have several times been driven away by the Indians. The situation of this rancho, and the house, is such as one would least expect, being at the summit of the pass.

We passed a few miles beyond the house, and encamped on the eastern slope of the pass, at the side of a small mountain stream descending from the peak of San Bernardino. The banks of the stream at that point were high, and were composed of drift or detritus; no outcrops of granite or hard rocks were visible along its channel. The hills on the left at the northeast were rounded, and appeared to be sedimentary.

We had thus ascended without any difficulty from the valley of San Bernardino to the summit-level of the pass, and we found it entirely different in its character and appearance from any that were examined in the Sierra Nevada or the Bernardino Sierra. It can hardly be considered as a low ridge of the mountains, but appears as an absolute break or dislocation of the entire chain. It is wide and open, bounded on one side by the snow-capped Bernardino mountains, and on the other by the sharp, imposing peak of San Gorgoño. The distance, north and south, between these mountains at the divide is from two to three miles, and the lowest ground appears to be at the base of San Gorgoño. The ascent to the highest point from the Bernardino valley is gradual, and, as we have seen, over grounds capable of cultivation, and already occupied by farms and large cattle ranchos.

There are no rock formations that crop out along the trail; the whole substratum of the soil is loose drift, or sedimentary materials derived from the wearing down and disintegration of granite. At several places between the old ruins and the summit-level there are many remnants of a former extended slope, which once must have been united with those already described as flanking the base of the mountains at the Cajon Pass, and from which the present valley of San Bernardino has been excavated by the action of streams. The soil, formed by the minerals constituting the slope and the surface of the pass, is fertile and valuable for agriculture even at the summit.

November 14.—The camp-ground was well shaded by numerous trees growing along the brook; but a little further down the stream all the trees disappeared, and the water was fully exposed to the sun's rays. As it was thought possible that there might be thermal springs on

this side of the mountain, as upon the other, the temperature of the stream was observed, and found to be 57°; air, 60°. This was at sunrise.

San Gorgoño Mountain.—We began the descent of the eastern slope towards the Colorado, and I left the train and crossed over to the south side of the pass to examine the rocks of San Gorgoño mountain. The height of this mountain was estimated to be between six and seven thousand feet. It rises abruptly from the pass to a sharp-pointed summit; its base is deeply cut by numerous re-entering angles, and long, narrow ridges extend from it in various directions. These radiating ridges have singularly rugged and serrated outlines, and showed out in bold relief, with sharp edges and angles; and there is but little verdure to hide them from view. The rocks are granitic and metamorphic, and have peculiar characters, differing from the granitic rocks of the Sierra Nevada and the Bernardino Sierra, but they simulate those developed in the ridges of the Great Basin along the Mojave river. The most important peculiarity of the rock consists in its highly laminated condition, and the frequent intercalation of thin layers or belts of white limestone, conformable with the planes of lamination. At a point about seven miles distant from Weaver's rancho, and a little east of the divide, I ascertained the trend of the granite to be N. 5° to 10° W.; and several miles east, lower down the slope, in a projecting spur, the trend is still more to the west, being nearly N. 40° W. The layers are vertical. The following is the succession and composition of the rocks:

a. 20 feet.—Feldspar and quartz in coarse crystalline masses, containing tourmalines.
b. 40 to 50 feet.—Micaceous and gneissoidal, containing large garnets.
c. 20 feet.—Granite, more compact.
d. 20 feet.—White saccharoidal limestone, with parallel layers of a dark color.
e. 15 feet.—Quartz rock.
f. White, fine-grained granite.
g. Gneissose.
h. White crystalline limestone.
i. Granite, or gneiss, (much mica.)

This projecting spur is nearly northwest from the peak of the mountain, and is the first part of the mountain that extends far out into the pass.

Rocks cut by driving sand.—A deep bank of drifted sand has accumulated on the east side of this point of rocks, it having been blown over by the wind. The wind which thus transports the sand is not an ordinary shifting breeze, but is a constant and powerful current of air sweeping through the pass from the west. It pours in from the Pacific in an apparently unbroken, unvarying stream, passing over the surface with such violence that all the fine grains of sand are lifted from the dry channels of the streams, and are driven along the descending slope until they find a final resting place to the leeward of the projecting spurs of San Gorgoño. In respect to this prevailing current of air flowing inland from the Pacific, the pass appears to have the same relation to the interior valley of the Colorado that is held by the Golden Gate at San Francisco to the interior valley of the Sacramento and San Joaquin. They both appear to be great draught-channels from the ocean to the interior, through which the air flows with peculiar uniformity and persistence, thus supplying the partial vacuum caused by the ascent of heated air from the surface of the parched plains and deserts.[1]

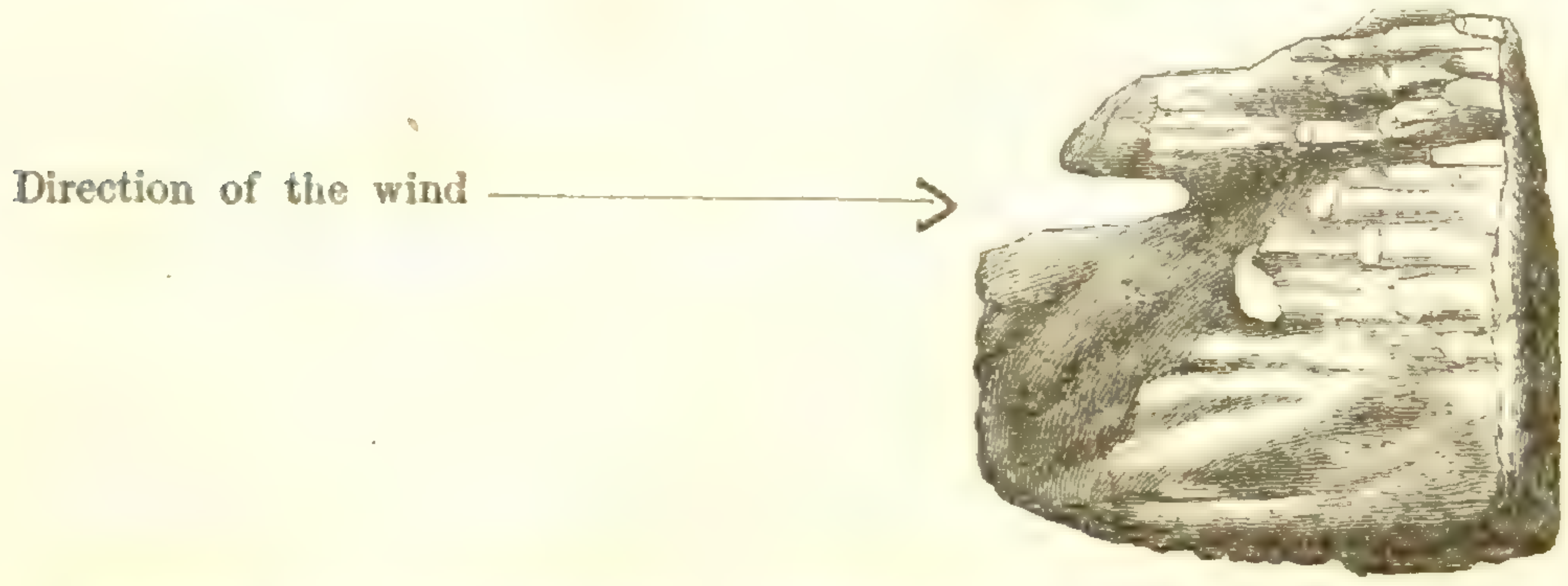
I had before me remarkable and interesting proofs of the persistence and direction of this air-current, not only in the fact that the deep sand-drift was on the east side of the spur, but in the record which the grains of sand engrave on the rocks in their transit from one side to the

[1] It is very desirable that meteorological observations should be made at this pass. There are, doubtless, strongly marked periodical variations in the direction and force of this great air-current.

other. It would be difficult to find a place where the cutting power of drifting sand is more beautifully and clearly exhibited than it is at this point. The whole surface of the rocks was smooth and polished, and even the limestone had a peculiar, rounded and smooth surface, which resembled that of partly dissolved crystals, or deliquescent specimens of rock-salt. Long parallel grooves, deep enough to receive a lead-pencil, were cut on the surface of the hard and homogeneous granite. But the most striking and interesting examples were the effects produced on the portions of granite that were composed of large crystals of feldspar, quartz, and tourmaline, and also containing small imbedded garnets. These masses of minerals, differing in their hardness, were unequally cut away. The feldspar, being the softest, was most rapidly acted on, and even the quartz and garnets were unequally abraded, the amount of wear on each mineral being in the order of its hardness. The masses of quartz, tourmaline, and garnet thus acted as protectors to the portions of feldspar behind and under them, while the exposed parts were most rapidly chiseled out by the sharp grains, leaving the harder minerals standing in relief, or with the feldspar standing even with their surfaces on the lee side only, thus forming, in minature, a kind of tail, similar to the accumulations of earth and stones on the lee side of obstructions in a current of water.

The effects produced on the vertical surfaces of the rock exposed to the wind were, perhaps, the most curious and interesting, for here the hard minerals were left standing out in points, the softer feldspar being cut out on all sides. Masses of feldspar and quartz thus presented very rough and uneven surfaces. A part of the rock, which was detached, is represented in the annexed figure—the projecting points being quartz, and the mass of the specimen feldspar; the whole having a beautifully smooth surface.

ROCK, CUT BY DRIVING SAND.



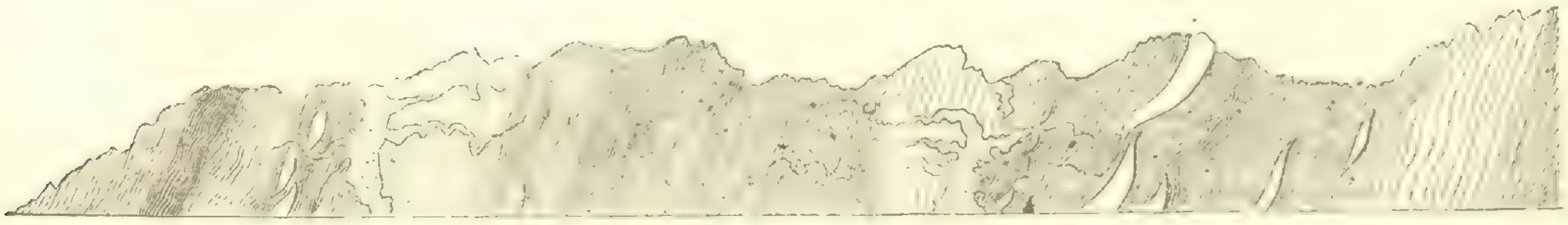
Where the feldspar was charged with small garnets, and was directly in front of the wind, a very peculiar result was produced; the garnets were left standing in relief, mounted on the ends of long pedicles of feldspar which had been protected from abrasion under the garnets while the surrounding parts were cut away. These pointed masses or needles of feldspar, tipped with garnets, stood out from the body of the rock in horizontal lines, pointing, like jewelled fingers, in the direction of the prevailing wind. They form, in reality, a perfect index of the wind's direction, recording it with as much accuracy as the oak trees in the vicinity of San Francisco, where, if the wind reaches them, they are bent from the perpendicular in one direction only, or in some places lie trailed along the ground. All the little points of stone pointed westward in the direction of the valley of the pass, to which the wind conforms.[1]

We continued travelling to the southeast, and downwards over the broad slope of the pass,

[1] A more extended notice of these phenomena of drifting sand and sand-polished rocks was communicated to the American Association for the Advancement of Science at Providence, in 1855, and will be found in the Proceedings. See also Amer. Jour. Science, second series, vol. xx, September, 1855.

following the shallow bed of a brook in which water was flowing rapidly, but without trees or much vegetation on its banks. It appeared as if it had been entirely dry for the greater part of the summer. On reaching the next extended spur of San Gorgoño, we encamped on the eastern or lower side, in order to avoid the strong wind which continued to blow without cessation. A considerable quantity of sand was found here also, and on the lee side of the rocks. The point was long and low, and the rocks were perfectly bare and very much broken. It was composed of a succession of granitic, gneissose and slaty rocks, intercalated with limestone and quartz rock, similar to those before described. The trend of the planes of structure was found to be the same, (N.W. and S. E.,) dip N. E., about 40°. The peculiar laminated structure, and constant alternation of gneiss and mica slate, with narrow layers of limestone, was well shown. All these layers were much contorted and bent, and were traversed by numerous feldspathic veins. An extended sketch-section was made of this point of rocks, and a portion of it is presented here, and will serve to indicate the characteristics of the rock.

SECTION ON THE EAST SIDE OF SAN GORGOÑO.



l, l, l, limestone; *g, g,* granite, or feldspathic veins; *s, s, s,* gneiss, mica slate and granite.

The limestone formed lenticular beds, from one to eight or ten feet in thickness, conformable with the slaty rock, and partaking of its flexures and contortions. The slight thickness of these beds, and their lenticular form, led me to regard some of them, at least, as segregations. There was not time before dark to make measurements of the breadth of the different layers of rock, and indeed it would scarcely be possible to do it, as the variations between the compact and granitic portions, and the gneiss and finely laminated mica slates, were very gradual, and no distinct lines of demarcation could be found.

The stream of water flowed at the base of the rocks in a shallow bed of sand and gravel, and not a tree or blade of grass was visible on its banks. A short distance below, it spread out over the gravelly surface, and became completely absorbed by the sand. Our camp was near the piles of drifted sand, and the wind continued to blow through the night, and brought with it the grains of sand, making a rustling sound as they poured over the rocks and settled in all the hollows and crevices which the wind could not reach.

We had travelled twenty-two miles from the summit, and were nearly at the base of the pass, or at about the same elevation as the valley of the Santa Anna river at San Bernardino.

November 15.—The aspect of the country around the camp was peculiarly dreary and desert-like; towards the east and southeast a broad plain extended, and was bounded in the distance by brown and barren-looking mountains. They are represented in the engraving, but appear too near, and the plain too narrow. Grass and vegetation among the rocks, and clouds in the sky, have also been added by mistake. It is seldom that an artist is called upon to picture a scene so barren and desolate. The timber upon the mountains gradually disappears after passing the summit of the pass, and none is found on the eastern or inland side. Huge specimens of the melo-cactus were, however, abundant among the rocks.

We travelled southeasterly over the now broad and plain-like slope of the pass, and continued to descend. Several spurs of San Gorgoño were passed in succession; they extend out for a

great distance from the mass of the mountain, which thus appears furrowed by rugged and precipitous cañons. Each spur, as far as examined, presented rocks similar to those already described, the trend also being northwest and southeast, and the dip about forty degrees. The rocks appeared in jagged points all over the mountain, and no soil or vegetation could be seen. Large beds of limestone were, however, observed, much thicker and more extensive than the exposures seen before. It rests in inclined beds, conformably with the gneiss or mica slate, and is belted or marked by bands and lines in the same direction. Thin seams or veins of granite

VIEW FROM CAMP NEAR THE DESERT.

and of quartz were also seen in parallel layers. Crystallizations of hornblende and other minerals were observed at the line of junction of the beds with the granitic masses. This limestone is granular and crystalline, and is more or less blue, and is not as white and coarsely crystalline as the metamorphic limestones of New Jersey and New York.

COLORADO DESERT.

The ground over which we passed was gravelly and sandy. The sand was coarse, for all the finer particles had been removed by the wind. A range of hills, at the base of the mountains on the left, distant about ten miles, appeared to be composed entirely of sand, its surface being drifted into ridges.

Hot Spring.—After travelling about seven and a halt miles over these long and barren slopes, we saw a green spot in the distance, and soon came to two large springs of water rising in the bare plain, not far from the foot of the mountain. (See map.) One of these springs is warm,

and forms a pool nearly thirty feet in diameter, and three to four feet deep. The cold spring is not quite so large, and is only ten feet distant from the other. The water stands at the same level in each, and probably commingles, so that, on the side adjoining the warm spring, there is but little difference in the temperature, one being 120°, and the other 82° F. A constant odor of sulphuretted hydrogen rises from the water, and pails painted with white lead were turned black by it.

This place was evidently a favorite camping-ground for Indians. When we arrived, many Indian boys and girls were bathing in the warm spring, and a group of squaws were engaged in cooking a meal for a party returning from a great feast held near Weaver's ranch, and now just terminated.

A growth of rushes forms a narrow margin of green vegetation around the spring and its outlet. Willows and mezquite bushes grow there also; and I found a young *palm tree* spreading its broad, fan-like leaves among them. The surrounding desert, and this palm tree, gave the scene an Oriental aspect; and the similarity was made still more striking by the groups of Arab-like Indians.

The ground about the springs was raised so that a slight bank was formed around them. This bank may have been formed by the accumulation of sand around the moist earth, and among the roots of the plants and grass; or it possibly was thrown up by the springs, or by the Indians in cleaning them out.

We encamped at this place, not knowing how far we would be obliged to travel before water would again be reached.

November 16.—*Hot Spring to Deep Well*, 12 *miles.*—A slight dew was deposited on the blankets during the night, but this was probably local, and derived from the warm vapor of the spring. The water was covered with a cloud of condensed vapor, and its temperature at sunrise was only 86°, the air being 46°. It is thus affected by the changes in the temperature of the air, the supply not being very rapid. The barometer indicated an elevation of less than two hundred feet above the sea.

On leaving the green banks of this spring, we again traversed the bare and gravelly surface, and skirted the base of the mountains on the right. The rocks were much broken and piled together in confusion, the absence of soil and vegetation permitting every inequality to be seen. At one point these rocks were found to be composed of quartz, hornblende, and feldspar, in nearly equal proportions, forming a compact granite. The quartz and feldspar are disposed in small rounded grains, enclosed in thin films of mica. This gives a structural character to the mass, and determines a line of easy fracture. The trend of the planes of structure was northwest and southeast (magnetic.)

The whole aspect of the landscape was peculiarly dreary, and but little or no vegetation was visible. Numerous varieties of the cactaceæ began to make their appearance, giving a peculiar tropical character to the scene. Some of these plants were tall and cylindrical, four or five feet high, and grooved longitudinally.

Several drifts, and broad thin layers of blown sand were passed. The accumulations vary in depth from a few inches to fifteen feet; and the surfaces are beautifully smooth and rounded, and generally covered with ripple-marks, similar to those produced under water. As we proceeded, we found this sand rising into high drifts, which bounded our vision on the left, while on the right, the base of the mountains was not far distant. A narrow, but nearly level valley was thus formed. The soil appeared to contain a large portion of clay mingled with the sand,

and several low places, where water had been standing, were covered with a thin coat of fine clay, now cracked and curled up. Near one of these low places, we found the remains of an Indian bush-house, and the stubble of a barley-field. This barley had been raised at the foot of one of the highest sand-drifts. The sand was thus found to rest upon a substratum of clay, and beyond the field it was found to have a bluish-gray color, and to be very compact and hard.

The Indian guide conducted us over this surface of clay to "*Pozo hondo*," or Deep Well, a deep excavation in the clay made by the Indians to obtain water. It was at the base of a high sand-drift, and about twenty-five feet deep, but contained only a little water. It was wide at the top, but became smaller towards the bottom, being a funnel-shaped depression. The water was obtained by means of steps cut in the sides of the pit, the clay having hardened by drying so as to become like stone. This excavation appeared to have been made by the *hands* of Indians, for there were no marks of implements, and the clay that had been removed appeared to have been taken out while very moist and plastic. It is probable that it has been gradually formed, a little clay being taken out every season, or as often as the water failed or became very low. The soil for the whole depth of the well consisted entirely of fine, bluish clay, with a little sand. The surface of the ground was nearly level and floor-like, and extended from the base of the sand-drifts to the mountain, intersecting the rocky ridges with a sharp and well-defined junction, like that formed by a sheet of water, or the ice on a frozen lake. The opening to the well was shaded by several mezquite trees, as shown in the sketch.

SAN GORGOÑO MOUNTAIN, FROM DEEP WELL.

The peak of San Gorgoño rises in the back ground, the pass being on the right, over the line of sand-hills in the foreground.

We encamped, and before the mules were satisfied with water, it was all exhausted. It oozed

WATER LINE AND SHORES OF THE ANCIENT LAKE
(COLORADO DESERT.)

in through the clay very slowly, but appeared to be abundant ; about twenty buckets full were obtained in the course of the night.

November 17.—*Deep Well to Cohuilla Villages*, 13 *miles*.—Sand hills were observed on the left, or north of the trail, for three or four miles beyond the Deep Well, and formed a succession of low, rolling hills, or long drifts. For the greater part of the distance this sand did not extend to the rocks on the right; thus a clear space was left over which we travelled. The hard floor-like surface of the clay formed a good road for our wagons, which scarcely left the imprint of the wheels. The sand, in passing over this clay, when driven by the wind, had given the surface a fine polish by its attrition. The ridge on the right gradually became lower and appeared to be a spur from the mountains. The sky-outline was very peculiar, being extremely sharp and irregular, like the teeth of a saw. Such mountains surely merit the name *Sierra*. On reaching the end of this ridge, an unlimited view was presented towards the south and east. The broad plain of the Desert was before us, reaching to the horizon. On the right, it was bounded by the high mountains which extended down to the plain in successive ridges, one beyond another, until their blue outlines could hardly be discerned in the distance.

On turning around the point, I saw a discoloration of the rocks extending for a long distance in a horizontal line on the side of the mountains. On approaching this, it was found that the white color was produced by a calcareous incrustation, extending over the whole surface, and into every cavity and crevice. This crust had evidently been deposited under water, and, when seen at a distance of a few yards, its upper margin appeared to form a distinct line, which indicated the former level of the water under which it was deposited. This water-line, at the point where it was first observed, was only about fifteen feet above the general level of the clay, but it could be traced along the mountain sides, following all the angles and sinuosities of the ridges for many miles—always preserving its horizontality—sometimes being high up above the plain, and again intersecting long and high slopes of gravel and sand; on such places a beach-line be could traced. These evidences of a former submergence were so vivid and conclusive that it became evident to every one in the train that we were travelling in the dry bed of a former deep and extended sheet of water, probably an *Ancient Lake* or an extensive bay.

The shore-line upon our right was distinct and well marked by the incrustation, but the opposite shore or boundary of the former lake could not be so readily determined ; it must have been as far removed as the mountains on the other side of the plain, nearly fifteen miles distant. Portions of the calcareous crust were broken off from the rock and found to be cellular and easily crumbled, showing that the deposition had not proceeded by successive layers or crusts conforming to the surface. In the interstices of the incrustation, and in its mass, many small spiral shells were found ; they were also very abundant upon the surface of the clay, at the foot of the rocks, appearing to have been blown into heaps by the wind. They were so numerous in some places as to whiten the ground. Five or six species of the genera, *Planorbis*, *Anodonta*, *Physa*, and *Amnicola*, were soon collected, and showed that the former lake was of fresh water. These shells were not only on the surface but were imbedded in the clay. They were all white, being perfectly bleached, and were very perfect.[1]

The barometer at the well, having stood at about thirty inches, indicated that we were not much elevated above the level of the sea ; and the surface had gently descended from that camp to this point of rocks and appeared descending beyond as far as we could see. The view in the

[1] For a description of these shells, and others found on the Desert, see the results of the examination by Dr. A. A. Gould, Appendix, Article III.

direction of the Colorado river and the head of the California gulf being unbroken by mountains, it at first seemed as if the water had formerly extended up as far as this water-line and that we were then, perhaps, below the level of the sea, or that the region had been upraised so as to effect its drainage.

The valley or plain of the Desert was constantly expanding towards the southeast, the direction in which we continued to travel. The bounding ranges of mountains, limiting our view towards the north and northeast, gradually became more distant and less distinctly defined. A horizontal line, the beach-line of the former lake, was visible along their base. The surface of the desert appeared to descend by a gentle slope from the mountains on each side, the lowest ground thus being nearly midway between the ranges.

We passed several Indian trails, and about noon met an Indian family travelling in the opposite direction. The young men came first, carrying bows and arrows and an old flint lock musketoon; an old Indian and squaw followed, bearing the burdens. They stopped with surprise as we came up, and unrolling some rags from a great yellow ball invited us to eat. This proved to be made of the pounded beans and pods of the mezquite, which is an important article of food to them, but prepared in that way, and partly fermented, was not a very agreeable refreshment to us. The adjoining valleys in the mountains and the upper portions of the slope of the Desert are inhabited by a tribe of Indians called *Cohuillas*. Up to the time of our arrival their country had never been visited by the whites with a train of wagons. As we approached some of their villages, we passed several holes dug in the clay, two or three feet deep, that contained water, and were evidently springs that the Indians had enlarged. The largest and best of these springs were surrounded by extensive rancherias, or villages of huts, located in thick groves of mezquit trees, which were quite abundant, and grew so thickly together that the Indian huts were completely hid. The Indians came out in great numbers to meet us, some of them well mounted on horses, but most of them on foot. The women and children were also attracted by curiosity, but were very shy; many of them climbed to the tops of elevated platforms, where they appear to store their grain and melons, and thus obtained a good view of the long train as it passed to one of the springs where the grass was most abundant. We encamped at this place and were surrounded by crowds of Indians anxious to trade melons, squashes, corn, and barley, for pork, bacon, or other articles.

The chief, or "*capitan*," and the principal men having collected for a talk with Lieutenant Parke, they learned the object of our visit, and appeared much pleased. When questioned about the shore-line and water marks of the ancient lake, the chief gave an account of a tradition they have of a *great water* (*agua grande*) which covered the whole valley and was filled with fine fish. There was also plenty of geese and ducks. Their fathers lived in the mountains and used to come down to the lake to fish and hunt. The water gradually subsided "*poco*," "*poco*," (little by little,) and their villages were moved down from the mountains, into the valley it had left. They also said that the waters once returned very suddenly and overwhelmed many of their people and drove the rest back to the mountains. The vegetation around these springs was luxuriant, and wherever the clay was moistened, it supported either a growth of grass or of rank weeds. Saline incrustations were observed around the margin of the water, and on moist parts of the surface, some distance from it. Specimens were collected, (No. 261, of the catalogue,) and on examination are found to consist chiefly of common salt, with a portion of sulphate of soda, sulphate of lime, sulphate of magnesia, and carbonate of lime.

November 18.—*Cohuilla Villages to Salt Creek*—35 *miles*.—The Indians had a grand feast and dance during the night, keeping us awake by their strange songs and indescribable noises. At

4 a. m. the temperature of the spring was 56° and the air 52°. Our course was directed towards a projecting spur of the mountains, supposed to be about ten miles distant. The ground was principally clay, which by drying in the sun has become very hard, but on being cut and pulverized by the passing of the train became dusty, like dry ashes. On cutting down into it for about twelve inches it was found to be more sandy and micaceous, and a specimen was taken for analysis, (No. 263 of the catalogue.) It appeared to be a rich soil, for wherever water comes to the surface the vegetation is abundant, and a large area near the mountains was covered with a dense growth of weeds, the ground being moist.

Eight or nine miles from our camp at the villages we stopped at another spring, where the water rose to the surface in abundance, and formed a pool twenty feet or more in diameter, surrounded by an artificial embankment three or four feet high. The water was clear and good; its temperature at noon was 78°, and there appeared to be a never-failing supply. Indians were living here also, and appeared to have a good store of grain and melons, which they had raised in the vicinity. We remained at the spring until three o'clock, to rest the animals and prepare for a long march over the unknown region between us and Carrizo creek, where the emigrant road from the Gila enters the mountains. None of the Indians could be induced to go with us; they were afraid to venture, saying that there was neither grass nor water, and that we could not take the wagons. The mountains on the right extended off in spurs or long ridges, one beyond the other, exactly as before observed from the camp at Deep Well. Carrizo creek was supposed to lie beyond one of the distant spurs, and we travelled towards it, having taken the precaution to fill all our canteens with water.

About sunset we passed within two miles of a projecting spur of the mountains, upon which the water-line was remarkably distinct. Although it was evidently high above the general surface of the plain or slope, it looked as if it could be easily reached, and I left the train to go and take its altitude with the barometer. On arriving under the rocks I was astonished to find that those which had appeared so small and diminutive, in the distance, were huge masses of granite, from ten to thirty feet in diameter, piled confusedly together, leaving many large spaces and long galleries among and between them. The whole surface was covered with the white incrustation, so that the rock was completely hid from view. At many of the over-hanging projections of the rocks this incrustation had become detached, by its great weight, and had fallen down to the foot of the cliff in large blocks. These disclosed the fact that this calcareous investment was, in some places, nearly two feet in thickness.

The interior portions of this crust, that adjoined the surface of the rock, were more compact and solid than the outer parts; and, here and there, through the mass, a small spiral shell was enveloped. The outer parts of the masses were more open, and traversed by an assemblage of irregular tubes and channels; these extended to the surface in horizontal lines, and produced a series of irregular and convoluted openings, which give a peculiar coralline aspect to the mass and cause it to resemble an organic growth. I observed, also, that this crust was more highly developed, and that its thickness was much greater on the under or overhanging surfaces than on the upper portions of the rocks. It is difficult to give a satisfactory explanation of the cause of this peculiarity, and of the singular form of the outer surface of the crust, without supposing it to be organic in its origin. Its internal structure is not consistent with this hypothesis, as it appears to have been deposited in successive coats, one over the other, as if from waters highly charged with carbonate of lime. The peculiar tubular structure may have been, and probably was, produced by the roots or stems of aquatic plants. But, even if this were so, it is difficult to conceive how such extreme regularity should be given to all the

tubular openings, and to explain the winding channels separating masses of the crust from those next adjoining. The sketch (View) was taken a short distance from the point of rocks, and represents an outlying part of the spur. All the lower part of the outcrop was covered with the crust so as to present rounded surfaces only, but the upper portion was not covered, and the black and angular edges of the rocks were distinctly seen. A mass of rock, with a part of the calcareous crust broken off, has been introduced into the foreground by the artist, so as to convey an idea of the character and thickness of the deposit.

After clambering over the white crust nearly half-way up to the water-line it was found impossible to proceed further with the barometer, and it was therefore set up at the base of the rocks. The height of the mercurial column was found to be 30.248 inches. This was surprising, and indicated that we were at or below the level of the sea. The water-line was estimated to be about 100 feet above us.

When wandering over these great masses of rock, and standing in the once sub-aqueous galleries and passages, with their walls and ceilings of the coral-like crust, the surfaces looked so new and fresh that it was not difficult to imagine that I heard the measured swell of the waves resounding in the dim caverns, and it was impossible to resist a feeling of dread that the great waters might suddenly return and claim their former sway over the deserted halls.

From these rocks I obtained a fine view of the Great Desert, stretching off towards the south-east in a wide, apparently limitless, plain, its only boundary the unbroken outline upon the distant horizon. Not a green spot in all this wide expanse was to be seen ; the bald mountains near me were not only free from trees, but there was not even earth to cover the rocks. The mountains opposite extended off towards the east until they were lost to sight in a series of low summits of a deep-blue color. The intensity and richness of the colors of the distant hills was very striking and beautiful. Blue, purple, and red were the prevailing tints, and their clearness and depth were remarkable. They were delicately blended one with the other, and produced a most beautiful effect, which it is impossible to describe. This variety and intensity of color appears to be peculiar to that region, and is probably the result of the extreme purity and dryness of the atmosphere, which may be considered as almost free from the vapor of water. It is so transparent that small objects can be seen distinctly at extraordinary distances. At the time I witnessed the extraordinary and beautiful tints of the distant mountains, the sun was going down behind those on our right, and we were soon enveloped in their shadows. As these gradually lengthened their outlines were sharply defined on the plain, and their gradual extension and progress across the valley to and up the sides of the opposite range could be distinctly noted. The shadows were projected on the surface with a peculiar sharpness, the transition from light to shade being sudden and distinct. Although the tops of the opposite heights were still gilt by the declining sun, there was so little reflection and refraction of the light that we were almost in darkness.

As soon as the last summit of the opposite range was merged in shadow, a peculiar effect upon the air overhead was visible. The whole blue vault seemed traversed by bands of light and shade ; in fact, the shadows of the mountains were projected upwards into the air, forming rays of light and shade, and there was so little diffusion and refraction of the light that they were distinctly visible. These shadows, although in reality divergent, appeared to gradually converge until they were united in one point far off in the blue depths of the air, thus affording a sublime illustration of the laws of perspective.

Slope bordering the Mountains.—During the night we travelled over a long slope from the

POINT OF ROCKS COVERED WITH A CALCAREOUS INCRUSTATION.

Ancient Lake Colorado Desert

From a sketch by Chs. Koppel.

Lith. by A. Hoen & Co. Balto

RAVINES IN THE BED OF THE ANCIENT LAKE.

mountains, which was composed of gravel and boulders. Portions of it were undoubtedly of recent formation, and had been spread out by heavy floods from the cañons of the mountains. There were, however, large areas of surface that were evidently in the same condition as when left by the water of the former lake. On these portions, rounded boulders and large masses of rock were so thickly spread that the wagons could not pass over them. These were all incrusted on the upper or exposed portions with a dark-brown crust, evidently very different from the white variety that incrusted the shores. Some parts of this crust was of a dark-red color, and very hard. I turned over many of the rocks, and found that generally the incrustation did not extend below the surface of the gravel and clay in which they were imbedded. I was evidently standing on the bottom of the old lake, and but little or no change had taken place since the waters had retired. From the appearance of this slope, and the rocky character of the bottom, and the absence of the fine blue clay that forms the greater part of the surface of the old lake-bed, I was led to believe that strong currents from the adjoining mountains and cañons had entered the old lake near this point.

Ravines in the Clay.—The rugged and rocky character of the higher parts of this slope made it necessary to descend with the wagons to the more level and hard surface of the clay. Here, other impediments to our progress constantly occurred. The rains or floods from the mountains, in traversing the surface, had cut deep ravines, which extended for miles directly across our course. These were about as deep as their width, and their sides were vertical. They resembled great fissures rather than valleys of excavation. In some places they were so narrow that it seemed almost possible to jump from one side to the other, and yet they were from twenty to thirty feet deep.

These singular cuts in the clay are formed at numerous points along the slope from the mountains. Many of the ravines commence and attain their greatest depth within a distance of three or four hundred yards. Their upper portions consist of multitudes of diverging channels, spreading out like the branches of a tree. The water collected by these branches becomes concentrated in the principal ravine, and after flowing for a short distance it passes out upon a lower part of the slope, and again diverges into small channels. This was the general character of the ravines that we crossed, and several of them were miles in length, and so deep as to be impassable except at their upper and lower ends, where the depth is not great. It is probable that these deep cuts in the clay are formed by a sudden flood of water from the mountains, or perhaps, by unusual rains during the winter. We lost much time and expended much labor on these ravines; it was necessary to find a place where the wagons could be taken down into them, and then to find a convenient point at which to construct a road to draw them out on the other side. The bed of a small tributary, or side fissure, was generally selected, and leveled by shovels so that the mules could be driven up and down.

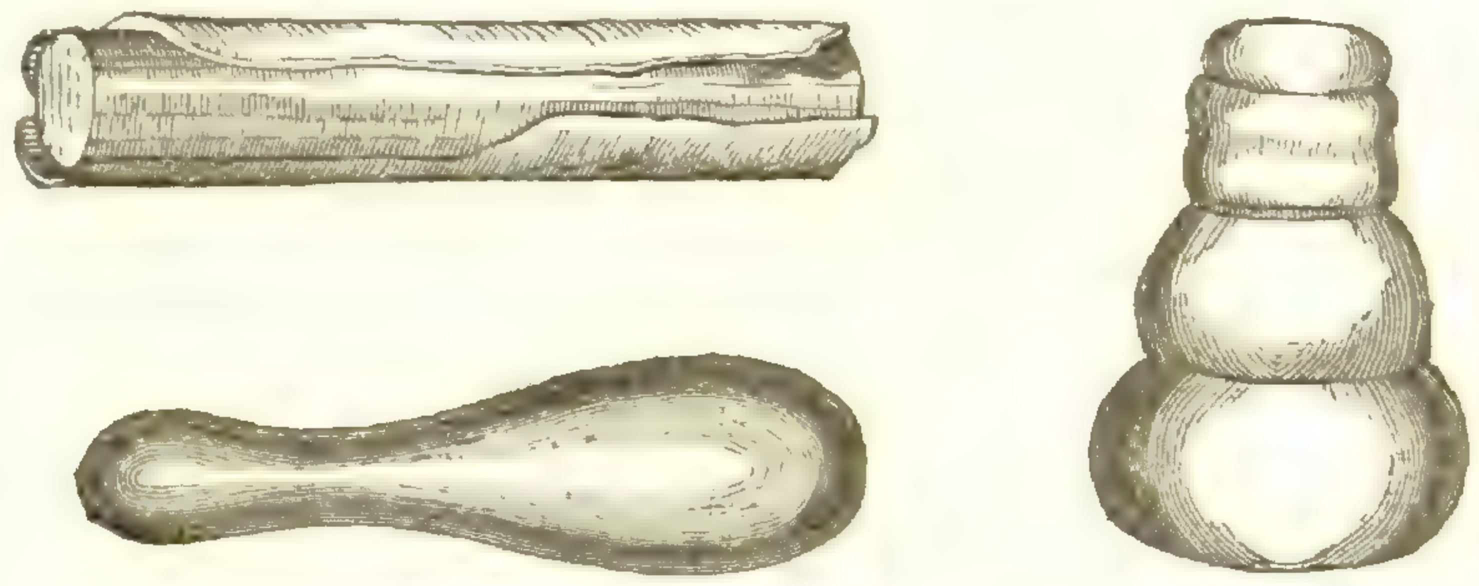
The vertical walls of these ravines were of fine clay in horizontal strata, sometimes mingled with sand, and varying in color from a grayish-blue to a light red; one or two layers of coarser materials, pebbles, &c., were observed in the upper parts of some of the sections, but may have been laid down by surface floods since the lake was drained. Multitudes of small spiral shells, like those found near Deep Well, were also visible, imbedded in the strata: but no specimens of Planorbis were seen.

We travelled among these ravines until after midnight, and the men and animals being exhausted, we lay down on the hard clay to sleep until daylight.

November 19.—Daylight showed that we had nearly reached the point of the mountains

towards which we had directed our course. We therefore, on starting, turned more to the right, expecting to turn the point and find Carrizo creek and the emigrant trail. We were, however, disappointed, and then kept on towards the next point. We soon found a change in the color of the soil, and left the bluish and reddish clay, and found a low ridge, formed of the upraised edges of a sedimentary strata, consisting of sandstones and clays, outcropping with great regularity, and extending in a direction twenty-five degrees west of north for a long distance.

These strata were mostly of fine clays of different colors, varying from grey to yellow, red, and pink. They were very thinly and regularly stratified, and altogether showed a thickness of over two thousand feet. These strata were filled with concretionary or nodular masses of all conceivable shapes and sizes. These were not only found in the sandy strata, but were also developed in the argillaceous beds in great number and variety.



CONCRETIONS, COLORADO DESERT.

The figures represent some of the forms that were procured. These curious and singular masses were found lying in long parallel lines upon the surface, being derived from the outcropping edges of the strata. One of the more sandy beds furnished great spherical nodules as large as ten-pin balls or bomb-shells. Some of the balls were connected together by a smaller sphere, which made them resemble dumb-bells. Other strata produced long, elliptical masses or cylinders, pointed at each end. The more clayey and finer sediments contained flattened ellipsoids, or kidney-shaped masses, and oblate spheroids of various colors, possessing a fine and smooth surface, which becomes polished by a little rubbing.

CONCRETIONS LYING IN LINES ON THE SURFACE.

Some of these masses were true septaria, and, when broken, exhibited numerous ramifying fissures, lined with crystals of carbonate of lime. Such was the variety of forms displayed on the surface, that it was not difficult to find specimens resembling various fruits and vegetables, fancy pastry, and confectionery. In nearly all of these strange and irregular forms the original planes of stratification were distinctly visible.

The greater part of the edges of these inclined strata were worn down to the general level of the slope, and we travelled over them; a portion, however, rose into a hill of slight elevation, and on its sides and top the calcareous incrustation was distinctly developed. Thus the Ancient lake registered its existence upon upraised Tertiary or Secondary strata, as well as upon the granite. We travelled nearly all day upon these strata, for the greater part of the time following the outcropping edges; but towards evening the road became so rough, and the prospect of a passage for the wagons in the hills beyond was so slight, that we retraced our way for two or three miles, and turned towards the north, crossing all the strata in succession. Their dip was

northerly, or from the mountains towards the low valley of the desert. Several of the beds were strongly colored by peroxide of iron; and gypsum, in clear plates, (selenite,) abounded in one of the lowest. No fossils could be found, but the strata were evidently comparatively recent, and are probably Tertiary.

As night came on, a mirage was seen in the direction of the Colorado river; the distant mountains loomed up with curious outlines. We were almost exhausted from exertion and want of water. The poor mules began to fail, and cried out in their peculiar, plaintive manner, evidently desiring water. As we neared the foot of the slope of the sedimentary strata, we found sand drifted into hills and banks like snow-drifts. These extended for a long distance on our left, and we travelled around and among them until we were suddenly stopped at the brink of a deep ravine, with precipitous banks of clay like those we had passed the previous night. Numerous specimens of *Anodonta* were found on the surface. It being nearly dark, it was decided to rest the animals until the moon arose before we attempted to cut a roadway down the sides of the chasm. At half past ten in the evening we succeeded, after great difficulty, in getting the train over, and then directed our course for another projecting range of hills, dimly visible by moonlight in the distance. The route was smooth, with the exception of an occasional drift of sand, for about three miles, and then we found a second great ravine, which caused considerable delay.

The extreme purity and clearness of the atmosphere on this desert becomes strikingly evident at night. The sky remained unclouded; and the stars shone out with that number and brilliance so characteristic of clear, frosty nights in the north; and the moon rose above the horizon with a clear, round disc, apparently unmodified by any vapors near the ground.

We travelled steadily along, all night, but found no signs of the emigrant road. Every hour became precious, for the mules were nearly exhausted; many had given out; and it became evident that the wagons and all heavy articles must soon be abandoned, in order to press forward for water. About four o'clock in the morning a change in the atmosphere was perceived; there was an occasional dampness, or sudden coolness, together with the odor of vegetable decomposition. These whiffs of cool, damp air were mingled with the dry, warm breezes of the Desert, and could be readily distinguished from them. The mules of the train were the first to recognize these indications of the proximity of water, and they became animated and pressed forward with eagerness. The riding mules pricked their ears and snuffed the air, while those that had been allowed to run loose in the rear of the wagons charged forward in a gallop. We soon reached the brink of a chasm or ravine in the clay similar to those before described, except that there was a small shallow stream of water at the bottom. The cry of "Water!" arose from those who first reached it, and it was repeated with loud shouts of joy from one end of the train to the other.

The stream was very shallow and the current sluggish, flowing over a bed of clay alone, which was so soft that it was hardly possible to cross it. In some places there was a border of green canes, tule, and coarse grass, which afforded a little refreshment to the animals. This water was strongly impregnated with common salt and sulphate of magnesia, and it deposited a thick saline incrustation on the borders of the shallows along its course. It was not very disagreeable to the taste, but coffee made with it was exceedingly nauseating. Its temperature at sunrise on the 20th of November was 48°; the air 40°, and at 12 m. 90°. Shells of all the species before observed were found here in abundance, and, in addition, several small and thick bivalves, (*Gnathodon Lecontei.*) With the exception of the Gnathodon, these were abundant on the surface, but were not found in the clay of the banks.

November 20.—*Salt Creek.*—We encamped on the border of this creek, and remained all day to rest the mules. Two men were sent forward to look for the wagon road, and returned in the evening with the report that it was about 20 miles distant. The rays of the sun were very hot, and the thermometer stood at 90° during the middle of the day. Some small specimens of silicified wood were found on the surface, and a perforated marine shell—a *Pecten*—which had probably been dropped there by an Indian. A small but regular rhombohedron of calcite was also found. This was perfectly clear, like Iceland spar, and was a perfect crystal, not being obtained by cleavage from a larger mass. The barometer at this camp stood at 30.4 inches for most of the time, thus indicating a depression below the sea-level—if 30 inches be regarded as the height of the mercurial column at that level. The ground towards the north and northwest was much lower, and there seemed to be little doubt that we were lower than the tide-waters of the gulf.

November 21.—*Salt Creek to the Emigrant Road, Carrizo Creek.*—At daylight on the morning of the 21st we again set out for the emigrant road leading from the mouth of the Gila, and for Carrizo creek—the first water in the mountains after crossing the Desert. The surface over which we passed, from our camp, was principally the hard, blue clay ; but near the mountains it was covered up to different depths by the detritus of gravel and sand which had been brought down and spread out by floods, forming slopes of gentle inclination.

Even the most level portions of the Desert in this vicinity have been much modified by the action of water. It appears to have re-assorted and distributed the argillaceous and sandy materials of the surface, alternately cutting away and filling up, as was shown by the exposed roots of mezquite and other shrubs peculiar to that region. In some places these stood out two or three feet above the surface ; and at others they were buried to the same depth. If it were not for these bushes, the modification of the surface would not be perceptible, as it is singularly flat and level. Where the clay predominates, it is so smooth and hard that it does not afford a secure resting place for grains of dry sand ; they are kept in constant motion by the wind, and have formed into long, parallel ridges or drifts, which appear to be progressing towards the southeast. These dunes or drifts were not deep ; the highest parts not being over ten feet above the underlying clay. They gave a gently undulating, wave-like outline to the surface.

DESERT TO WARNER'S.

As we approached the trail leading to Carrizo creek the surface became more uneven, and we passed over gravelly slopes, alternating with low and gently rising hills, covered with black, shining pebbles and rounded masses of volcanic rocks. The rocks and pebbles were spread over large areas, and appeared to be remnants of a drift deposit, older than the alluvial wash from the mountains. We also passed an isolated outcrop of granite, forming a slight knob in the plain, and trending north and south.

The emigrant road was at length reached, and we turned a sharp angle towards the mountains, proceeding in a northwesterly direction, and ascending the slope of the desert. Many low hills, covered with black and shining pebbles and cobble-stones, were passed along the road, and soon, outcrops of thickly-bedded argillaceous sandstone were seen. The dip appeared to be towards the west. The road, on gaining the upper edge of the slope, made a sudden descent into the valley of Carrizo creek, which was then entirely dry. The sides of the valley are formed of horizontal, or nearly horizontal, strata of clay and sandstone, and the hill which we descended was bordered on each side by bluffs of red strata, containing gypsum in thin

plates, much of it being detached and lying upon the surface. It being nearly dark, few observations could be made on these strata; they extended along the road for several miles, and formed bluffs from twenty to sixty or eighty feet in elevation. Before descending the hill, a specimen of *Gnathodon* was obtained. Water was at length found in the bed of the creek, and we encamped a short distance above, among some mezquit trees. A great quantity of bones of cattle and sheep showed the fatality which has attended the passage of the desert.

November 22.—*Camp on Carrizo Creek to Vallecito.*—The temperature of the stream early in the morning was 50°, and the air 44°. Nearly opposite the camp, the sandstone strata were similar to those seen in the Cajon Pass, and are formed of rudely commingled gravel and sand, and have a light, pinkish color. They are in thick beds, and not firmly consolidated. They were observed to have a westerly dip. Not far beyond, a dip of 17° was seen. Beyond the camp, and further up the creek, higher bluffs of nearly horizontal strata rose on either side. They were argillaceous, and contained seams of gypsum and concretions, some of the latter being like those seen on the desert. Passed a grove of palm trees, growing at a short distance on the right, the valley being one or two miles wide. The agave or *mescal* plant and many species of the cactaceæ grow abundantly along the road. The air was loaded with the effluvia rising from numerous carcases of cattle and sheep in an advanced state of decomposition. Reached Vallecito in the evening. This is a narrow valley, between high ridges of granite or gneiss and mica slate. The water was somewhat charged with sulphuretted hydrogen, and boils up from a grassy bank on the side of a low hill, upon which a rude adobe house, with one room, is built. There are no trees at this place, but the springs were surrounded with willows; there were many mezquit bushes, and the *Strombocarpa pubescens*, bearing the tournil or "screw bean." The temperature of the principal spring was found to be 78°, the air being 40°. The water in the shallow open pools was about 46°. It is probable that these are thermal springs.

November 23.—*Vallecito to San Félipe.*—We travelled up the narrow valley between the gneissoidal ridges on either side, and soon crossed the out-cropping edges of the rocks to another and more elevated valley. The mountains are rugged, and almost without soil; the rocks are blackened, or very brown, so that their true character or composition cannot be recognized at a distance. At San Félipe there are several Indian rancherias and small fields along the borders of the creek. The squaws were gathering mezquit beans, and some were seen carrying jars of water on their heads in true oriental style. At the sources of the small creek, a little higher up the valley and beyond the Indians, there is an abundance of grass and several springs of excellent water. The valley was much wider than that at Vallecito, and extended off among the mountains towards the south. Cotton-wood trees were visible in that direction, and other timber was seen on the elevated parts of some of the ridges. Encamped at the springs.

November 24 *to* 28.—We pitched tents, and prepared to remain for several days, or until the party arrived from the Mojave. On the 26th it began to rain, and continued most of the day, flooding the camp. On the 27th the tops of the ridges were covered by fog, and the sky continued cloudy. A man arrived from the west, over the pass—Warner's Pass—informing us that the remainder of the party had returned, and were encamped at Warner's.

November 28.—*San Félipe to Warner's.*—Left camp and travelled up the valley, finding granite and gneiss along the road to the summit of the pass, where a compact gray granite makes its appearance. The whole aspect of the country was changed, oak trees and shrubbery were abundant, and grass grew along the side of the road. A short descent from the summit-level (about 3,500 feet above the sea) brought us to a broad valley, known as Warner's. Its

surface was covered with a luxuriant growth of grass, and the mountains around were covered with vegetation. We passed the ruins of Warner's adobe house, which it is said was burned by the Indians, and soon reached the camp of the main party, situated on a grassy plain, near the shore of a small pond or "lagoon."

The valley is well situated for raising stock, and it is large enough to afford pasturage for immense herds. It is used for that purpose, and is a comfortable resting place for the droves of cattle and sheep that are brought in over the desert from New Mexico and Sonora.

Warm Springs.—The thermal springs, generally known as "Agua Caliente," are situated on the slope of one of the ridges at the northeastern part of the valley. They have long been resorted to by Indians for bathing, and the cure of various diseases. The water boils up out of a granite ledge through a number of openings or cleavage fissures, and in one place it appears to have enlarged the opening, so that it has become nearly cylindrical. The water flows copiously from the different apertures, and the united streams give a volume of water about equal to what would be delivered from a two-inch pipe under a pressure of one or two feet. These openings are in a slight ravine, which appears to have been the bed of a brook that is now deflected from its course by a dam, built for the purpose by the Indians. In descending towards the spring, the odor of sulphuretted hydrogen is at once perceptible; and a slight cloud of steam rises from the water. The temperature of the water at the different openings was taken, and the following are the results: Time, 9 a. m., November 30.

1st or principal spring	temperature, F.	142°
2d spring,	"	141°
3d spring,	"	140°
4th spring,	"	140°
5th spring, 10 feet distant,	"	136°
Stream below the springs,	"	130°
Stream above the springs,	"	58°
Temperature of the air,	"	74°

Bubbles of sulphuretted hydrogen were constantly escaping, and the water was highly charged with it, and had an acid taste that was quite agreeable. There was only a slight incrustation or deposit on some of the rocks. On those near the spring I found a slight yellow film, thickest at the edge of the water in the quiet pools; this was afterwards found to consist almost wholly of sulphur. A small jet of steam or air was constantly issuing from a crevice near the main spring, producing a slight hissing sound like steam from a leak in a boiler.

The granite at this locality is compact and hard; it has a coarse grain and texture, and a light-grey color. The proportion of mica and hornblende is small, but they are uniformly distributed in fine grains.

The mass is traversed by cleavage planes or fissures in two or more directions, but this regularity or parallelism was not sufficiently distinct to enable me to determine the direction or angles of intersection. Some of the principal ones trend north 9° east to north 12° east, (magnetic.)

Higher up in the bed of this brook, on the side of the mountain, the granite appeared nearly the same as that just described. I observed, in addition, that it contained lenticular, hornblendic, and micaceous masses, similar to those seen in the granite of the Sierra Nevada, at the Tejon Pass. The color and texture of this granite is similar to that at the divide, and it has a trend north 5° west.

All these granite ridges are well wooded with several varieties of oak, and in some places a thick growth of shrub oaks. The soil of the valley is formed of the materials of the granite, and the luxuriance of the grass and vegetation testifies to its good quality.

CHAPTER IX.

WARNER'S TO THE COLORADO DESERT—COLORADO DESERT TO THE MOUTH OF THE GILA—CAMP YUMA AND THE VICINITY.

WARNER'S TO SAN FELIPE.—GRANITIC VEINS.—GRANITE AND GNEISS.—VALLEY OF CARRIZO CREEK.—DRIFT.—FOSSILS.—VIEW OF THE DESERT.—SIGNAL MOUNTAIN.—MIRAGE.—DISTORTED IMAGES OF MOUNTAINS.—SLOPE OF THE DESERT.—FOSSIL SHELLS.—POLISHED PEBBLES.—SILICIFIED WOOD.—BIG LAGOON.—LITTLE LAGOON.—WATER COURSES.—NEW RIVER.—ALAMO MOCHO.—WELL.—SKELETONS OF CATTLE.—MEZQUIT.—LARREA MEXICANA.—SAND.—MOUNTAINS.—PILOT KNOB.—MEZQUIT WELLS.—COOK'S WELL.—CONTINUOUS BANK OR TERRACE.—CONGLOMERATE.—SAND-DRIFTS, DUNES.—WILLOWS AND COTTON-WOODS.—INDIAN VILLAGE.—FERTILITY OF THE SOIL.—COLORADO RIVER.—RED MUD OR SILT.—PILOT KNOB.—BLACKNESS AND POLISH OF THE ROCKS.—GRANITE.—VOLCANIC OR ERUPTED ROCKS.—TRAVERTIN.—AGATES.—PEBBLES FILLED WITH FOSSILS.—CONGLOMERATE.—PLAIN OF THE DESERT.—DUST.—FORT YUMA.—PORPHYRITIC GRANITE.—CHIMNEY PEAK.—SECTION OF THE BUTTE AT FORT YUMA.—SECTION ALONG THE RIVER.—INCLINED STRATA.—PROBABLE ORIGIN OF THE FISSURE IN THE BUTTE.—EARTHQUAKES.—MUD VOLCANO.—MOUNTAINS NEAREST THE FORT.—PLAIN COVERED WITH POLISHED PEBBLES.—GLITTERING SURFACE.—AGATES AND PORPHYRIES.—SILICIFIED WOOD.—GNEISS.—VIEW OF THE DESERT AND SAND-HILLS.

December 1.—*Warner's Valley to San Felipe,* 16 *miles.*—We left the camp at Warner's and commenced the journey to Fort Yuma, at the mouth of the Gila, thus retracing our steps over the mountains to San Felipe and Carrizo Creek. Arrived at San Felipe at 4 p. m. The temperature of one of the springs at camp was found to be 68 degrees.

December 2.—*San Felipe to Vallecito.*—Large veins of granite, or feldspar and quartz in coarse grains, are very numerous in the granitic or gneissose rocks along the route. In some places they cut the gneiss nearly at right angles to its dip, and at others are parallel to the layers. At San Felipe the veins are of great size, and immense, imperfect crystals of tourmaline were observed. On approaching Vallecito, I turned to the left of the road, just before crossing a spur of the mountain, and followed the course of a small brook, then nearly dry. This led me through a narrow gorge which was invisible from the road, but which opened out into the next valley. The ascent of the spur was thus avoided, but the trail was impassable for wagons. Great blocks of granite and gneiss were abundant in this gorge, the mountains on each side being composed of these rocks. Reached Vallecito in the afternoon, and encamped near the springs and adobe house.

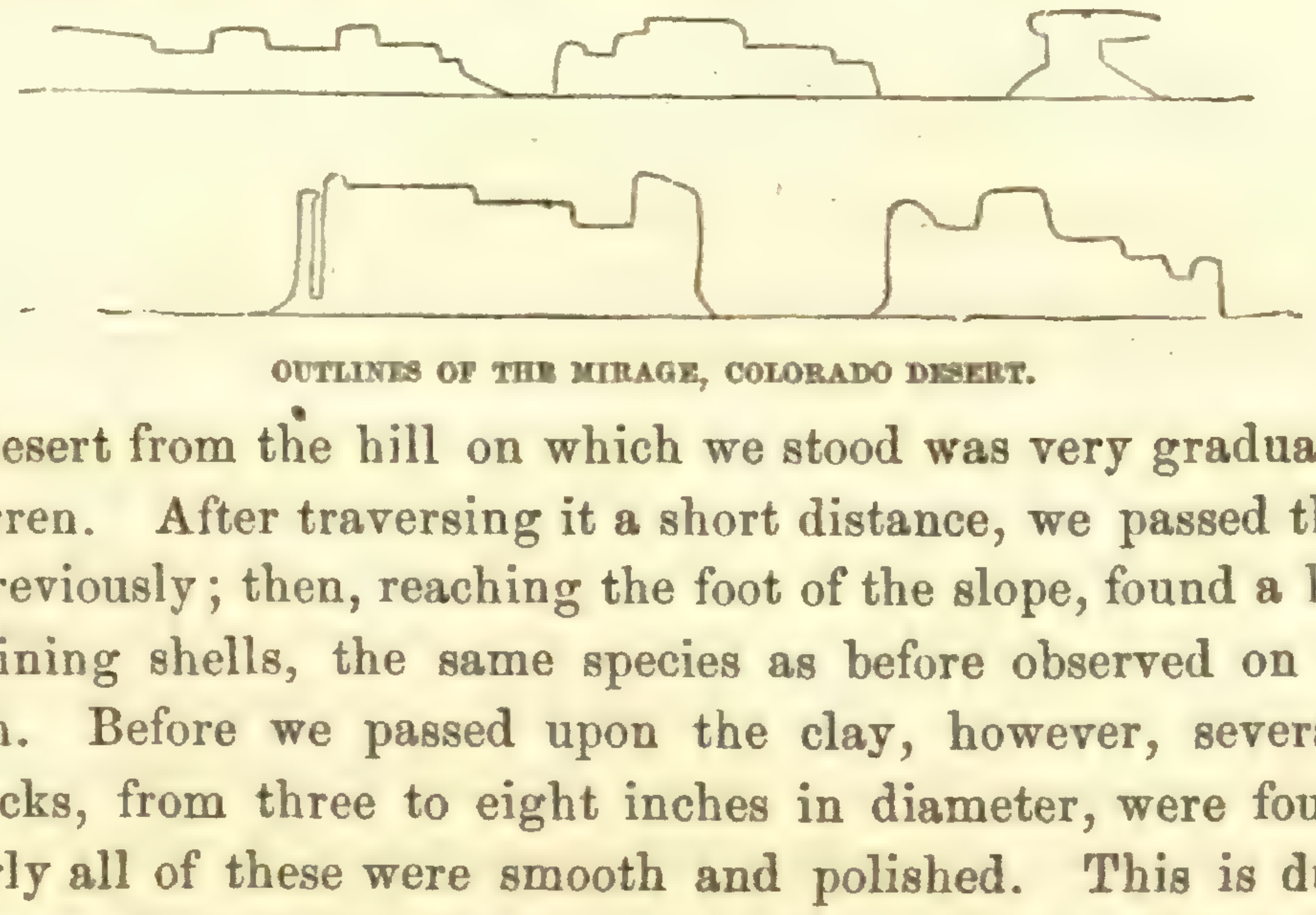
December 3.—*Vallecito to Carrizo Creek.*—After obtaining a supply of barley, which was stored in the adobe house, we travelled towards the desert, following the same road previously traversed by me when with Lieutenant Parke. The general dips of the sandstone strata along the creek appeared to be southeast and southwest, but as the inclination of the strata is slight, and they are cut in many different directions, as many different degrees of inclination and direction of dip were apparent. We passed the usual camping ground on the creek, where the bones and skulls of animals paved the ground, and following the water down to the point where it sank away in the sand, we tied our mules to the limbs of the mezquit bushes and spread our blankets on the clean, dry sand. A party of Sonorians, with several ladies, arrived shortly afterwards from the desert, and encamped just below us.

December 4.—*Carrizo Creek to the Big Lagoon,* 25 *miles.*—The dry bed of Carrizo Creek is extremely sandy, rendering it difficult for the animals to draw the wagon. Sandstone hills were

found on each side for several miles from the camp, as before observed. It is through these that the creek has cut its channel, and, where the stratification remains horizontal, the tops of the hills are flat and covered with water-worn boulders and thick layers of pebbles, which are, apparently, the continuation or source of the accumulations of drift already noticed as covering the slope of the desert near the mountains. One of the isolated hills a short distance north of the trail was found to be capped by a thick layer of fossils, closely impacted together. Several specimens were detached very quickly, and further observations were deferred until our return, as I was already far behind the party. These fossils were chiefly oysters and pectens. Just before reaching the hill which leads up to the long slope of the desert, we *cached* a sack of barley, to be fed to the mules on our return. The fossils I had procured were also hid, and the whole was covered with sand.

The ascent of the hill leading up from the valley of the creek brought us to a full view of the broad expanse of the Great Desert. It lay stretched out before us, a vast plain reaching to the horizon, the only mountains visible being those on the northeast side, rising dim and faint in the distance, and a single isolated ridge, much nearer and almost south of us. This was *Signal mountain*, a solitary peak, serving as a guide to the traveller when on the desert. The road could be traced down the slope extending off to the southeast, this being the direction of the mouth of the Gila in the Colorado, about 90 miles distant. The phenomena of mirage added greatly to the grandeur of the scene, supplying the forms of mountains or buildings upon the distant edge of the desert; tall blue columns loomed up on the horizon, and castles, towers, and the spires of cathedrals, seemed to stand beyond the limits of the great plain. Their outlines were distinctly projected against the morning sky, but they were undergoing constant change, becoming lower or higher, and occasionally spreading out like a cross, or merging together into one grand pile.

Some of the outlines were sketched and are represented in the figures; but they convey no idea of the beauty of the scene. See, also, View XII.



OUTLINES OF THE MIRAGE, COLORADO DESERT.

The slope of the desert from the hill on which we stood was very gradual, and the soil firm, but gravelly and barren. After traversing it a short distance, we passed the trail made by the wagons a few days previously; then, reaching the foot of the slope, found a hard, smooth surface of bluish clay, containing shells, the same species as before observed on the portions of the desert further north. Before we passed upon the clay, however, several accumulations of drift-pebbles and rocks, from three to eight inches in diameter, were found along the trail. The surfaces of nearly all of these were smooth and polished. This is due to the continued action of the blown sand and dust in its passage over them. The greater part of these masses are of volcanic origin, and many specimens of scoriaceous and vesicular lava were found. Fine specimens of silicified wood were also found to be abundant and of various sizes, from one or two inches in length to as many feet. They are generally of a brown color, and retain all the appearance of wood; the grain and knots show distinctly, and resemble the wood of the mezquit. The surfaces of these specimens were also curiously polished, and some of them appear to have been deeply cut and grooved by the moving sand.

Three or four miles beyond the foot of the slope we reached the margin of a small pond of muddy or slimy water, called the *Big Lagoon*, and encamped. This lagoon was very shallow, and the shores shelving and miry, so much so, that it was difficult to obtain any of the water. The water was slightly brackish and bitter, had an unpleasant odor, and was very warm. Chenopodiaceous plants were abundant.

December 5.—*Big Lagoon to Alamo Mocho—twenty-six miles.*—The surface of the desert continued the same—a level and hard clay A mile or two beyond the Big Lagoon we came to the edge of another and smaller one, called the *Little Lagoon.* It is much like the first, except that it is bordered by mezquit trees, which, in some places, grow very thickly together. The shores are muddy and shelving. We passed two canal-like channels, or wide gullies, in the surface, with mezquit trees growing in the bottom, and evidences of the presence of water at a former period. Shells of *Anodonta*, and small spiral shells, were abundant. These channels probably communicate with the two lagoons, and may be the bed of the stream called *New River;* so called from the fact of its sudden appearance in 1849. At that time the Colorado River was very high, and broke over a part of its banks between the mouth of the Gila and the head of the Gulf. The water flowed inland, running backward through the desert towards the centre of the valley once occupied by the ancient lake; thus proving the valley to be lower than the banks of the river at the place of overflow. Major Emory and party, who crossed the desert from the Colorado to Carrizo Creek in the year 1846, does not mention this stream, or any indication of its pre-existence. He mentions, however, that he was informed by a Mexican that a running stream would be found a league west of the Alamo. Parties were sent out to search for the water, but no stream could be found. [1] The appearance of the stream in 1849 was a subject of general surprise and wonder; and was an unexpected relief to the many emigrant parties who crossed the Desert that year. It is the general belief that this overflow was the first instance of the kind, but it has evidently often taken place before, and there are many reasons for believing that it once flowed in a larger and stronger stream than it has since its existence became known. The lakes are connected with New River, and are filled by it when the Colorado is high. Since the appearance of the stream, a part of the travel across the desert has been diverted from the usual course, in order to have the advantage of its waters and the margin of grass and tule along its banks. When, however, the channel is not filled with water, the old route is preferred. We did not follow the river, but kept the road towards the well and camping place known as *Alamo Mocho.*

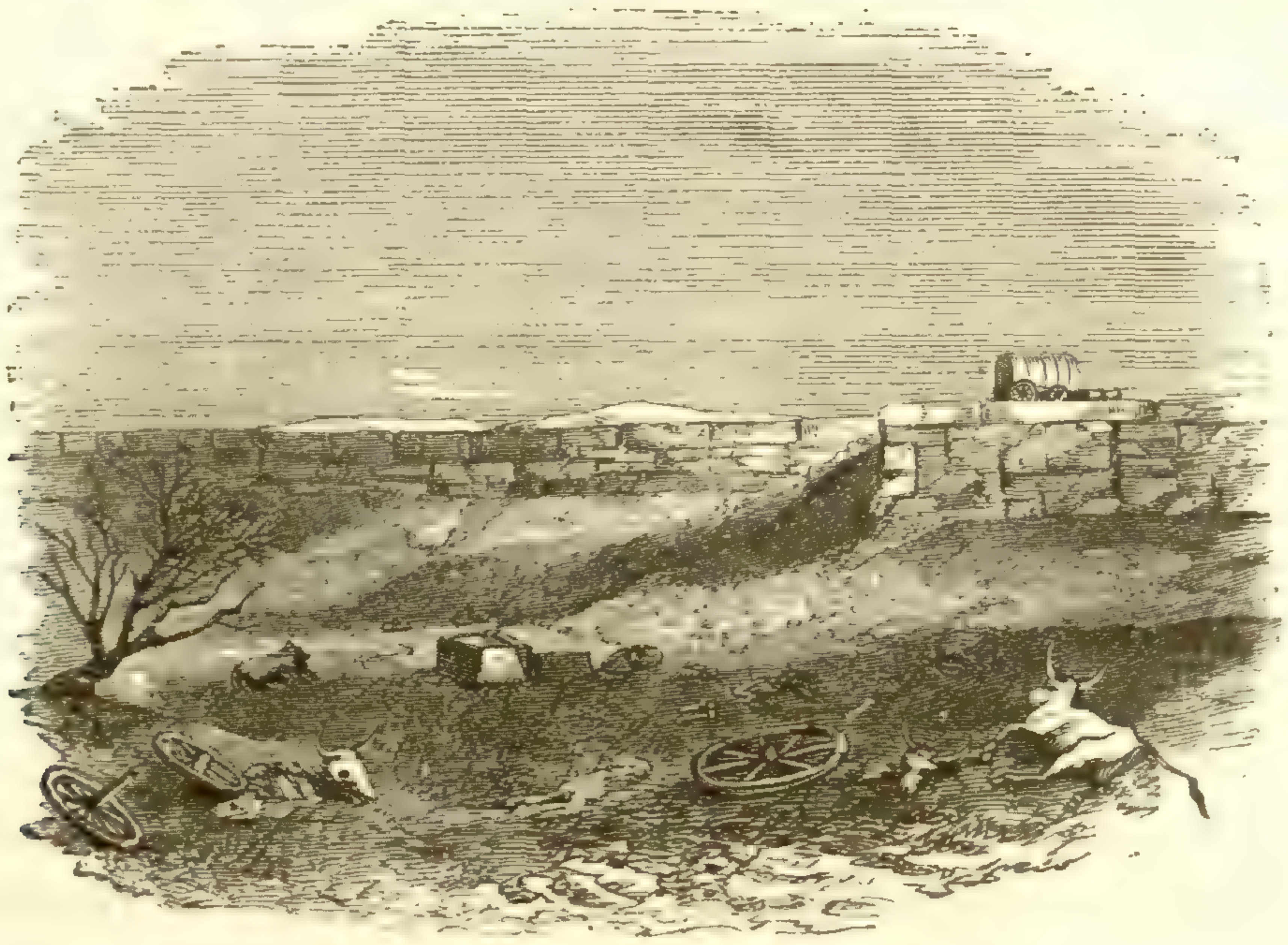
The surface of the desert, between the lakes and Alamo Mocho, is slightly undulating; but, to the traveller, it appears to be level.

After passing the lagoons, there is but little vegetation; and about half-way (13½ miles) from Big Lagoon to the well we passed a thin layer of drifted sand, and the surface became more gravelly.

Alamo Mocho.—The name of this place appears to have been suggested by the abundance of cotton-wood trees that grew there several years ago, and that have been cut down. One or two decaying trunks were all that remained. Our camp was on the margin of a steep bank of clay, about thirty feet high. The well is dug at the foot of this bank, in one of the lowest places, and appears to be in the dry bed of a water-course, or canal, similar to that seen near the lagoons. The desert beyond the well, south and southwest of the camp, appeared lower than the plain on which we were, and was sparsely wooded with low, and partly dead, mezquit bushes. The well was about eighteen feet deep, and lined with boards, and protected by a low curb; but

[1] Report of Major W. H. Emory, p. 100.

there were no buckets or conveniences for drawing the water. This water was found to be turbid, and slightly brackish. The country around the camp was peculiarly dreary and desert-like. Quantities of skeletons of cattle and mules, with loose bones and skulls, were lying about in confusion. Near the well were several carcases but partly decomposed, and others completely dried up, so that the skeleton was held firmly together by the hard and tightly-stretched hide. The clay surface upon which these remains were distributed was perfectly barren and overlaid by a thin coat of dry sand, which the wind drifted into little mounds, and moved about with a low, rustling, and mournful sound.



WELL IN THE DESERT—ALAMO MOCHO.

The bank above the well, as represented in the engraving, appears like a wall of stone, but it is nothing more than an indurated clay, of a reddish and gray color, very fine and regularly stratified in horizontal layers. A specimen of the clay of a bluish-gray color was preserved, (No. 162 of the catalogue.) No shells or fossils were observed.

December 6.—*Alamo Mocho to Cook's Well*, 22 *miles*.—The trail from the Alamo well winds along on the top of the bank. The surface is slightly undulating, and is overspread with considerable accumulations of gravel and pebbles. We passed many slight mounds, ten or fifteen feet high, upon which large shrubs of *Larrea Mexicana* were firmly rooted, and had evidently been growing in the same position for many years. At a short distance, these mounds looked like sand-hills; and it is often the case that a thin layer of blown sand spreads over or around them. They are also composed essentially of sand; but the grains appear to be bound together with fine clay or dust, so that they resist the winds and are not shifted about.

Eleven and a half miles beyond the Alamo well we crossed the point of a thin layer of blown sand that had accumulated about the roots of the larrea, which grew abundantly in that vicinity.

There was little to vary the monotony of the scene on this broad Desert, except the gradual changes in the appearance of distant mountains as we neared or receded from them. Signal mountain was now behind us, and gradually sunk below the plain; while on the left the mountains loomed up one range after another in long blue lines. Another object made its appearance in advance: the blue summit of a mountain rose just above the horizon, and became higher and higher as we advanced. This was Pilot Knob, an isolated elevation on the banks of the Colorado.

About fifteen miles from the Alamo well the road descends from the bank or terrace to the level of the low ground already described as seen from the camp at the well. Thick groves of mezquite trees extended on all sides, and were sufficient indications to me that the ground was well supplied with water, at a moderate depth.

Mezquite Wells.—These are dug on the low ground along the trail, and were mere holes scooped out in the clay to a depth of six or eight feet. In one of them a keg, or barrel, had been sunk, and was partly full of brackish, muddy water. The mesquites grow very thickly about these wells, and attain a large size. We travelled for many miles among them, occasionally passing across several acres where all the trees were dead, and gave the country the appearance of a dried up swamp, or of a forest that had been killed by the influx of water. These mezquite trees continue along the road to Cook's Well. The trail winds along under and near the bank or terrace, which rises on the left and presents an almost uniform bank, about thirty feet high. The larrea grows in clumps on the top of the bank, and is often a nucleus for the driving sand, which accumulates about the roots wherever the force of the wind is broken.

Cook's Well.—This was dug in the clay under a bank or terrace, about thirty feet high, similar to that at the Alamo and Mezquite well. It was also nothing more than a hole scooped out in the clay, and the water was small in quantity and slightly brackish. It could not be obtained clear, as it was surrounded by fine clay, and held a large amount of it in suspension. A good well, lined with plank, would remedy this difficulty and afford abundance of water.

December 7.—*Cook's Well to the Colorado River,* 15 *miles.*—The trail beyond Cook's Well passes over a level clay surface, and among groves of mezquite, similar to those already described. A continuous bank or terrace extends on the north of the trail the whole distance. This bank was about thirty feet high, and nearly perpendicular. Near the well it was formed of clay, with a superficial coating of gravel and sand ; but at the Indian village, (Algodones,) near to the Colorado, there was a thick upper stratum of pebbles and rounded stones, about as large as hens' eggs, held together by a cement, which appeared to be carbonate of lime.

Sand-drifts.—The greater part of the bank just described was hid from view by a thick covering of blown sand, that had accumulated into drifts and hills on its top and near to its edge. In some places these drifts had progressed so far as to fall over into the plain below, filling up the angles formed by the steep bank, and presenting a gradual slope of sand. These were the principal and most formidable sand-hills that we had yet met.

As we came within six or seven miles of the Colorado, the groves of mezquite were gradually replaced by clumps of willows and tall cotton-wood trees, many of which were dead, and one or two, near the high bank on the left, were partially buried in the blown sand that had fallen over its edge. Two miles from the Colorado, we descended a bank ten or fifteen feet high, at the Indian village, located at the base of the sand-hills. A spring at this place furnished the Indians with water, and numerous shallow canals (*acequias*) showed that it was obtained in quantity sufficient for purposes of irrigation.

These Indians cultivate the ground around their village and raise corn and melons. One of the fields was covered with the dead stalks of maize; and an Indian boy brought me ears of corn to exchange for tobacco. Immense quantities of sliced melons and yellow pumpkins were suspended from poles to dry, and large piles of the seeds were spread out on platforms for the same purpose. These form an important part of the food of the Indians. There can be no question of the fertility of this region, and of the clay soil of the Desert, at any point where water can be obtained in sufficient quantity for irrigation.

Colorado River.—At the time of my visit the river was nearly at its lowest stage, and was flowing rapidly, about twenty feet below the edge of the bank The water was highly charged with fine, red mud, which gave it a decided red color and opacity. This red clay receives its color from a large amount of peroxide of iron ; considerable quantities of it were deposited in all the shallows and quiet places along the banks.

The amount of silt thus annually transported to the Gult of California by this river must be very large, and very considerable additions to and alterations of its delta must result.

From the Algodones, (or the Indian village near the Colorado,) the trail followed up the right bank of the river, winding about in a thick growth of willows. The terrace and sand-hills still bounded the view on the left, and were about half a mile distant from the stream.

We soon reached Pilot Knob, which had so long been visible at a distance, and, in fact, is a well known landmark or guide to the traveller of the desert. It rises, solitarily, above the level plain, about three miles distant from the point of the range that borders the desert on the north-east. The whole surface of the rocks is of a jet black color, and they have a peculiar polished exterior which glistens in the sun as if it had been varnished or highly polished. Lines of structure or lamination were, however, distinctly visible in the granite, and were much bent and contorted. Their trend is about 5° W. of N. (magnetic.) The Knob also appears to be traversed by dykes or ridges of a dark volcanic rock, which resembles basalt, or some dark varieties of crystalline trap. I had not time to follow out and determine the line of junction between the granite and this rock.

The granite was traversed by narrow seams and fissures, which were filled up by a cellular and porous substance, apparently a calcareous sinter or travertin.

On the rocks of this Knob, about forty or fifty feet above the level of the river, I found numerous rounded agates and carnelians, and a mass of rolled and water-worn flint, which contained small fossil shells, apparently Carboniferous or Cretaceous. All these pebbles and the loose fragments of the rock were highly polished, and presented a dark brown or black color, glistening in the sun's rays like polished ebony or japanned ware.

The sand-hills terminate near the western side of Pilot Knob, but the bank or terrace upon which they are formed appears to be continuous beyond the Knob to the vicinity of Camp Yuma. Its upper stratum, at Pilot Knob, is a bed of conglomerate about five feet thick, similar to that occurring back of the Indian village. The pebbles are closely and firmly cemented together or imbedded in a paste of carbonate of lime, and they are principally fragments of volcanic rocks of various colors, some of them being dark red and green porphyries of great beauty. This conglomerate is underlaid by strata of sand, in an unconsolidated state, and they much resembled post tertiary deposits.

The river makes a great bend near this ridge, and almost washes its base, leaving a space so narrow between the rocks and the bank that the road leads over a low point of the Knob. A fine view of the Colorado and the timber along its banks is presented from the elevation ; it is seen to curve around towards another but much smaller butte—the site of Fort Yuma—about eight miles distant. The bank or terrace, which was found to border the trail after leaving Cook's Well, is seen to be the margin of an elevated and level plain extending between the mountains, and perfectly devoid of trees or vegetation ; while the lower ground or bottom-land along the river is covered with groves of mezquite, willows and cotton-wood. The accompanying sketch was taken from the Knob, looking up the river, and a little north of east, and shows the plain on the left, and the peculiarly sharp and pointed outlines of the distant moun-

tains. The road crosses the hill in the foreground, and follows the curvature of the river to Camp Yuma.

VALLEY OF THE COLORADO, FROM PILOT KNOB.

We remained at the foot of Pilot Knob over night, intending to reach Fort Yuma early the next morning. Our camp-ground was very dusty, the soil being light and dry, like ashes, and a high breeze from the north kept the dust in constant motion, filling every open vessel, and covering garments and blankets with a thick layer. The temperature of the air through the night was very agreeable, being about 70°, and the water of the river in the afternoon was found to be 58°.

We reached Fort Yuma early the next morning, (December 8,) and were most hospitably received and entertained by the officers of the post.

JUNCTION OF THE GILA AND COLORADO RIVERS—FORT YUMA.

Fort, or Camp Yuma, is situated upon an isolated butte or knob of porphyritic granite, not over one hundred feet in height above the river, and of small extent. The waters of the Gila river, coming from the east, flow into the Colorado just at the eastern base of the elevation. It is the only eminence within a circuit of eight miles, and thus commands an extensive panoramic view of the Desert and mountains by which it is surrounded on all sides. The Colorado may be traced both north and south, bordered on each side by wide, desert plains. On the south, towards the head of the Gulf, these extend as far as the eye can reach, unbroken by a single mountain ridge. On the east, the narrow stream of the Gila winds down from the mountains,

bounding the vision in that direction. Northward and eastward, the most striking feature of the landscape is found in the extraordinary outline of the mountains. Gigantic columns and domes of mountain size rise high into air, above the lower but still rough and angular outlines of the ridges. An idea of their forms may be obtained from the little outline sketch, but no

CHIMNEY PEAK, FROM FORT YUMA.

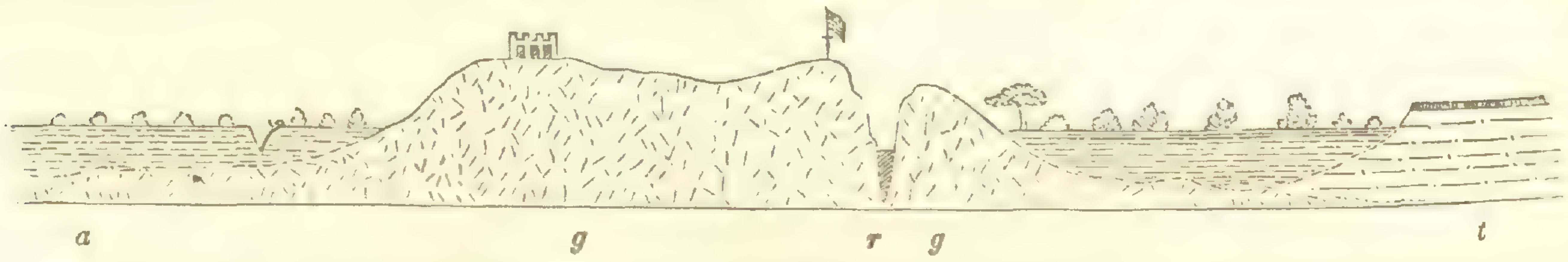
conception of the desolate grandeur of the scene can be obtained without looking out upon it. The highest of these peaks is called *A-melle-e-quette*, by the Yuma Indians, and Chimney Peak by residents of the fort. The "Dome Rock" has the Indian name of *Ar-with-a-que*, (pronounced as written.) They are about twenty miles distant from the fort. These pinnacled ranges are represented to be of granitic rocks by intelligent parties, who have visited portions of them, from Camp Yuma. Chimney Peak is also reported to be formed of sandstone strata standing on edge.

The principal and most distinct of the dome-like rocks is called "*Capitol Dome*;" it is not included in the sketch, but one is seen of a similar shape. The vertical, wall-like sides of these rocks simulate the weathered remnants of horizontal fields of basalt, or the vertical bluffs of trappean formations. These elevations were too far removed and inaccessible to be visited during my visit at the fort. They are very singular, and are worthy of a special examination.

The granite of the knob contains large crystals of feldspar, and is thus a porphyry or porphyritic granite. It is probable, however, that the rock varies in different parts of the hill. Several irregular veins of dark-colored hornblende and epidote were exposed in a natural section along the river, and, from their ramified and peculiar character, I concluded that they were of volcanic origin, and probably of comparatively recent intrusion.

It is a curious fact that the Colorado cuts directly through this elevation of granite, instead of circling around it, where it could readily excavate a channel in the clay. Indeed, there is an old, dry channel on the north of the butte, which becomes filled at the time of high water, thus, for a time, making an island of the butte.

SECTION OF THE COLORADO RIVER AT FORT YUMA.

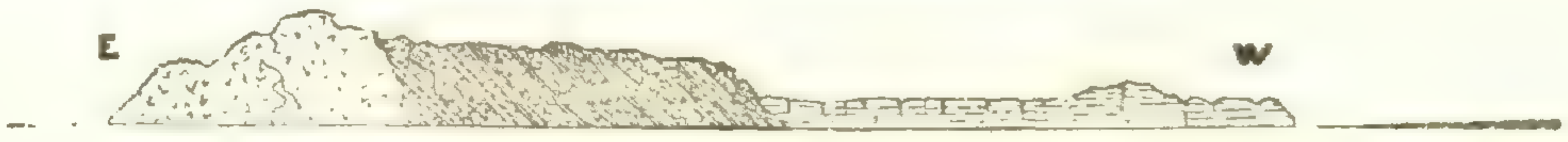


a, Alluvium. *g*, *g*, Porphyritic granite. *r*, Colorado river. *t*, Tertiary, or post tertiary sandstone.

The section from north to south, across the butte, will serve to show the relative positions of the granite, the Tertiary, or Post Tertiary, and the alluvium of the river. The walls of granite rise nearly vertical on both sides of the river, and being of the same height and outline, indicate that the butte has been cleft asunder, or fissured by some great convulsion of nature. Even the rock appears as if freshly broken, for it is not discolored and blackened by age as the outer portions are. The fissure, if such it may be considered, affords a good opportunity for

obtaining a section of the butte, and it exposes a series of inclined strata resting at an angle of about thirty-five degrees against the granite. The following sketch represents the outline and appearance of the south wall of the break through the butte:

SECTION ON THE BANK OF THE COLORADO.



g, Porphyritic granite. *s*, Inclined strata. *a*, Alluvium.

The inclined strata dip to the west, and are not found on the eastern, or "*up stream*," side of the granite; but on the western or lower side they occur similarly on each bank of the river. These strata are, apparently, composed of blocks and fragments of the same granite upon which they lie, and seem to have been derived from its degradation. They are not much water-worn, and are rudely stratified, alternating with beds of light-colored clay and gravel formed of the same rocks.

This singular formation probably does not extend beyond the butte, and the appearances indicate that the materials were laid down in their present inclined position. If so, rapid currents must have acted on this granite barrier when it was at a lower level than now. The position of the debris involves the necessity of believing that the currents flowed from east to west, or in the same direction as the river. It does not appear possible that the deep gap, with nearly vertical walls, through which the river now flows, can be the result of degradation by the stream, even if the gradual elevation of the rock be allowed. The butte being the only elevated ground within a circuit of seven or eight miles, and being surrounded by loose, sedimentary formations, we would naturally expect the river to form a channel *around* the barrier, instead of cutting through it. I am therefore disposed to consider this cañon as a deep fissure, resulting from volcanic disturbances.

Earthquakes.—Fort Yuma and its vicinity appears to have been particularly liable to volcanic disturbances or earthquakes, for many have been experienced since the establishment of the military post. On the 9th of November, 1852, the camp was violently shaken by an earthquake, and the shocks continued almost daily for several months after, and were so frequent and expected as not to excite remark. At the time of our visit the shocks had not entirely ceased, and I was informed that they had become "*quite rare, none having been felt for fully three weeks!*" The first shock threw down a portion of Chimney Peak, and opened fissures and cracks in the clay strata of the Desert bordering the Colorado. At the same time, Major Heintzleman, the commanding officer of the post, observed a column of steam rising from the Desert, in a southwesterly direction, at the distance of about forty miles. Several weeks afterwards, he visited and examined the locality, and found a small mud volcano, in an active state.[1] Puffs and jets of steam, mingled with large masses of black mud, were being constantly ejected to the height of thirty or forty feet. The orifice was in a shallow basin, partly filled with water, covering a surface of several acres. This was violently thrown outwards, in waves, at the time of each explosion; its temperature was found by Major H. to be 108°. Numerous little cones were puffing out steam, like the exhaust of a small high-pressure steam engine; and in one of these, where gas and steam were issuing, the thermometer indicated a temperature of 170° Fahr.

Another mud volcano was found about the same time, in the northwestern part of the Desert,

[1] See Map of the Desert for the position of this volcano.

northeast from Salt creek, and probably near the lowest point of the bed of the ancient lake. Clouds of dust were thrown up from various parts of the Desert at the time of the principal shock, and the probability is, that there were many small openings and rents for subterranean gasses, that have never been found, or that have since been entirely obliterated.

The position of these, the most important and active vents, and the fact that they were opened in the lowest parts of the surface, and through the recent clay formations subject to overflow, indicates a connexion of the phenomena of disturbance with the infiltration of water. No overflow of the Colorado, however, was known to have taken place that season; but rain had fallen in the months of July, August, and September, preceding the earthquake.[1]

December 9—Fort Yuma to the mountains north of Pilot Knob.—In company with Lieutenant Hendershot I made a trip to the mountains northwest of the fort, and nearly north of Pilot Knob. The mountains are near the end, or at that point form the end, of the apparently continuous range extending southeasterly from San Bernardino mountain, and bounding the valley of the Desert on the north and east. We estimated the distance to the nearest point of these rocks at thirteen miles; they, however, seemed to be much nearer, and to be separated from us by only a narrow belt of river-bottom and of the plain beyond. To an observer from the Atlantic States, whose eye had not become educated in estimating distances in that region of lofty peaks and pure air, the distance would have appeared to be less than half its reality.

Our course, at first, lay over the bottom-lands of the Colorado, among cottonwoods, willows, and clumps of mezquite trees. We soon passed from these to a wide area covered with gigantic Chenopodiaceous weeds, through which it was not easy to force a passage with our mules. We saw beyond us, the borders of the upper plain, marked by a horizontal line, apparently about thirty or forty feet above the level of the bottom-land. This line was broken at short intervals by gullies worn out from the top to the bottom of the bank by drainage water during the showers, leaving in some places long projecting points of the plain between two gullies. These little valleys, thus formed by erosion, were from twenty to sixty or one hundred feet in width, and were bounded by steep banks of the horizontal strata on each side. In some places the thick bed of conglomerate, which overlies the sand, was visible, and in others, it had been gradually undermined and washed away until the height of the bank was much reduced. The bottom or floor of these little valleys was sandy, and strewn in places with pebbles from the conglomerate. A large quantity of black sand was also found covering the surface of ripple-marks, and in some places it was so abundant as to form black patches of several square feet in area and from one-quarter to half an inch in depth. A sample of this was collected, and is found to contain many small, but beautifully formed, garnets. In the solitude of these narrow valleys, excavated below the level expanse of the desert plain above, I was agreeably surprised to find several forms of vegetation of unique and peculiar appearance, many of them, doubtless, yet undescribed. One of the most conspicuous was a large shrub, or tree, probably the green-barked Acacia of Major Emory and others. It forms a low tree which spreads out over a large surface, but at that locality did not rise higher than the level of the adjoining banks.

The foliage is light and airy, and not unlike that of the mezquite or screw-bean in its general aspect, but is quite different in color, being a whitish or ashy-green. The limbs and trunks are round and very smooth, and the bark is greenish-white. The plant is so peculiar and striking in its appearance that it cannot fail to arrest the attention of the most casual observer.[2]

[1] The author is indebted to Major Heintzelman, U. S. A., for these facts.

[2] Specimens of this plant and others, were subsequently collected by Major G. H. Thomas, United States army, and are described and figured by Dr. Torrey in the Appendix.

On ascending from the shallow valley, along one of the side ravines, we found ourselves standing on the broad, level expanse of the plain of the Desert. The mountains towards which we were travelling rose up from this plain, but were apparently not much nearer to us than when we started. The outlines of the nearest ridges were sharp and distinct, and their color was a dark reddish-brown ; while the more distant points of the range were various shades of purple and blue. From our feet to the base of the mountain the surface seemed unbroken, and almost perfectly level; there was not a single swell of the ground, a tree, shrub, or boulder of rock, to break the monotony of the level expanse. Pebbles of various colors, like those found at Pilot Knob, lay in profusion on the surface. We had not proceeded far before we found that the ground was literally paved with them, and that, in fact, but little earth or sand was to be seen. These pebbles were not loose, as upon an ordinary gravel-walk, but seemed laid down compactly, as if by art, and all at the same height, as if they had been pressed down by a roller, or otherwise. We were, in fact, upon the surface of the layer of conglomerate which caps the horizontal strata below, and which was seen in section at the Indian village and beyond Pilot Knob. The size of the pebbles varies from that of a hickory nut to a hen's egg, and larger ; but the greater part are not larger than an egg. They consist, as before observed, of various colored porphyries, and of basalt and greenstone, mingled with quartz, agates, and jaspers. The whole surface of the plain was swept clean by the winds, and the upper layer of pebbles was perfectly clean and free from soil, sand, or dust. All the cementing material seemed removed, and they were retained to the surface by a narrow but firm bedding on the under side. Every pebble had the beautifully polished and glistening exterior, and the diversity of colors was increased, and their brilliance heightened, by this singular polish. The glitter of the sun's rays on this plain was like that on the water of a lake in a summer's day, when the surface is thrown into ripples by a passing breeze. Each pebble seemed firmly placed, and yet could be readily detached. The galloping of our mules made a strange clinking or rattling sound, but scarcely left a trace of our passage behind us. We, however, crossed several long, path-like discolorations of the surface, extending for miles in nearly straight lines, which were Indian trails. The only change which was produced appeared to be the removal or dimming of the polish on the pebbles. There was no break in the hard surface, and no dust. That the distinctness of the trail was made by removing the polish only, became evident from the fact that figures and Indian hieroglyphics were traced, or imprinted, on the surface adjoining the path, apparently by pounding or bruising the surface layer of the pebbles. These trails seemed very old, and may have endured for many generations.

While travelling over this brilliantly-paved plain, its surface shining with myriads of polished pebbles of agate, jasper, and carnelian, the attention was constantly attracted, at short intervals, by some stone of pecular form or unusual color, and it was difficult to resist the temptation to dismount and examine them. Several masses of a brownish hue, and not rounded like the pebbles, but elongated and irregular, were seen. A stroke of my hammer on the end of one of these broke it across, and revealed the most exquisite and beautifully preserved organization of wood. Each cell and pore could be distinctly traced, ranged within concentric circles, which were the lines of annual growth, and showed that the plant was exogenous. Although the exterior was dark-brown, the interior, as exposed by the fracture, was of a light buff color, veined with red and brown in varied tints due to the coloration of the silica, which had permeated the pores of the wood by iron or other impurities. The portion contiguous to the external surface, for the depth of about one-eighth of an inch, was nearly white and opaque,

like chalk, and appeared to have been produced by the long exposure of the specimen to the weather. This difference between the color of the interior and the surface showed, in a manner very striking, the peculiar surface discoloration which is found on all the rocks of that region, and which it is yet impossible to explain.[1]

Having at length arrived at the base of the range, it was found to be composed of naked rocks, there being no soil or vegetation. The whole surface had that peculiar blackened and glistening appearance observed at Pilot Knob. The outlines of the range were very rugged and sharp, and long re-entering valleys or angles were numerous. We climbed to an elevation of about two hundred and fifty feet on the extreme point, and thus gained a full view of the Desert towards the north, west, and south. The ridge upon which we stood appeared to be one of many others extending similarly out into the Desert, and overlapping, thus bounding long, narrow valleys. It was, however, evident that it extended further south than the others, and Pilot Knob was in its line of prolongation, and apparently three or four miles distant. The butte upon which Camp Yuma was located was in full view, and the windings of the Colorado, with its green border of timber, could be traced in the plain far to the south. The space between the mountain and Pilot Knob was nearly level, and paved for the whole distance with the brilliant pebbles. There were, however, slight channels, or depressions of the surface, which indicated that the direction of the drainage was southwest.

The rocks were found to be compact gneiss, or gneissose granite, the layers being nearly vertical. Several white quartz veins, from three inches to a foot or two in thickness, were seen; one could be traced by the eye for a long distance on the side of the ridge. The sand-hills were in full view for their entire extent, and were seen to form a narrow belt only, and did not appear to extend far back from the bank or terrace commencing at Pilot Knob. The surface intervening between the hills and the ridge appeared to be hard and gravelly, and was free from sand. After taking many bearings to distant mountains, we returned to Camp Yuma.

[1] For a description of the structure of specimens of the fossil wood of the Desert, see Appendix, Article VI.

CHAPTER X.

FORT YUMA TO CARRIZO CREEK.—CARRIZO CREEK TO SAN DIEGO.

Remarkable cleft in the rocks of Pilot Knob.—Terrace.—Sand hills.—Extent and height of the hills.—Rain.—Rounded form of the grains of sand.—Agate and quartz.—Sand-storm.—Silicified wood.—Argillaceous strata.—Approach to Carrizo Creek.—Barren mountains west of the desert.—Erosion of Carrizo Creek.—Banks of horizontal strata.—Fractures of the strata due to earthquakes.—Gypsum.—Stratum of marine shells.—Silicified wood polished by sand.—Palm springs.—Vegetation of the valley of the creek.—Granite and gneiss.—Vallecito.—Basin-shaped valleys at different elevations.—Gneiss and mica-slate.—Veins of feldspar traversing the rocks.—Large crystals of tourmaline.—San Felipe.—Ravine near the Indian village.—Travertin of the creek.—Santa Isabel.—Granite.—Syenite.—Quartz veins and indications of gold.—San Pasqual.—Rounded hills of stratified formations.—Trap dyke.—Conglomerate.—Slope from the mountains.—Valleys of erosion.—Beach shingle.—Fossil shells.—Punta Loma.—San Pedro.—Bluff of argillaceous strata.—Bituminous shales.—Hard sandstone.—Sun cracks.—Modern deposits containing shells.—Bitumen.—Santa Barbara.—Fossils.

FORT YUMA TO CARRIZO CREEK.

December 11.—*Fort Yuma to Cook's Well.*—We left Fort Yuma at noon for Cook's Well, on our return across the desert, following, for the greater part of the way, the same trail over which we had passed in proceeding to the fort.

At Pilot Knob, further observations were made upon the rocks and the adjoining bank of conglomerate, and specimens collected. A great cleft, or fissure, about twenty feet wide, was observed in the mountain a few hundred yards back from the road. It seemed to have been the result of volcanic disturbances, but was not followed or examined. We left the trail by which we came, which follows down the bank of the river, and turned into a trail on the right, leading among willow bushes and trees almost directly at the foot of the bluff or terrace of sand and conglomerate. The sand-hills commence near the knob, and extend all the way to the Indian village, and beyond it. On arriving at the village, it was found that the top of the bank was still formed of a conglomerate, and the loose dry sand of the Desert was pouring over it, reaching the cultivable land below. These sand hills were continually in view on the right hand, the trail in some places being at their base. On ascending them from the trail, and travelling among them, every other object was lost sight of, and nothing but the wave-like outlines of the drifts could be seen. The steepest slope of all the hills was towards the south, and the northern slopes were found to be gradual—the sand gradually thinning down to the level of the plain. The highest hills, also, were on the south; towards the north side of the belt the altitude of the hills decreased. The highest hills were probably about sixty feet, but some were seen in the distance which may have been higher. The northern limit of the hills was seen, and the belt was probably less than half a mile in width. The progress of this sand towards the south appears to have been arrested by the steep bank and the mezquite trees.

Before reaching Cook's Well the sky became overcast with clouds, and rain began to fall. This is an uncommon occurence in that region and worthy of note.

December 12.—*Cook's Well to Alamo Mocho.*—It continued to rain through the night and during the morning, but the fall was not great. We reached the Alamo about sundown. I carefully

examined the sandy and gravelly surface near this camp, and found that nearly all the grains of sand were much rounded. Lying down close to the surface, I was able to pick up a great number of the grains of different colors, and found them to be rounded fragments of quartz crystals, chalcedony, carnelian, agate, rose-quartz, and a green mineral, probably chrysolite. The spherical form is undoubtedly produced by the constant attrition of the grains as they are driven before the wind.

December 13.—*Alama Mocho to the Big Lagoon.*—Soon after leaving the Alamo Well we descended to the level of the hard clay, which forms a perfect plain without vegetation. The small shells, already noted, were very abundant. One or two small sand-hills—the accumulations about an old mezquite bush—were seen. We arrived at the margin of the Big Lagoon in the evening, and experienced a very high wind, which drove the sand and dust before it in clouds, and partly filled the tracks made by the wagon wheels. The sand moved along near the ground with a rustling sound, but the finer particles of grit were elevated into the air and driven with blinding force.

December 14.—*Big Lagoon to Carrizo Creek.*—The wind blew violently during the night, and we found, after starting, that it had blown the sand into thin drifts across the trail, filling up the ruts and tracks. These little drifts were only two or three feet wide and from one to six or eight inches deep. On reaching the slope leading up to the mountains, I secured many fine

BARREN MOUNTAINS WEST OF THE DESERT.

specimens of silicified wood. It occurs in great abundance, lying loose on the surface, and in places, tons of it could be collected from an area of one or two acres.[1]

In one of the slight gullies, or depressions in the surface of the plain, about half way between

[1] For a description of a specimen of the wood, see Appendix.

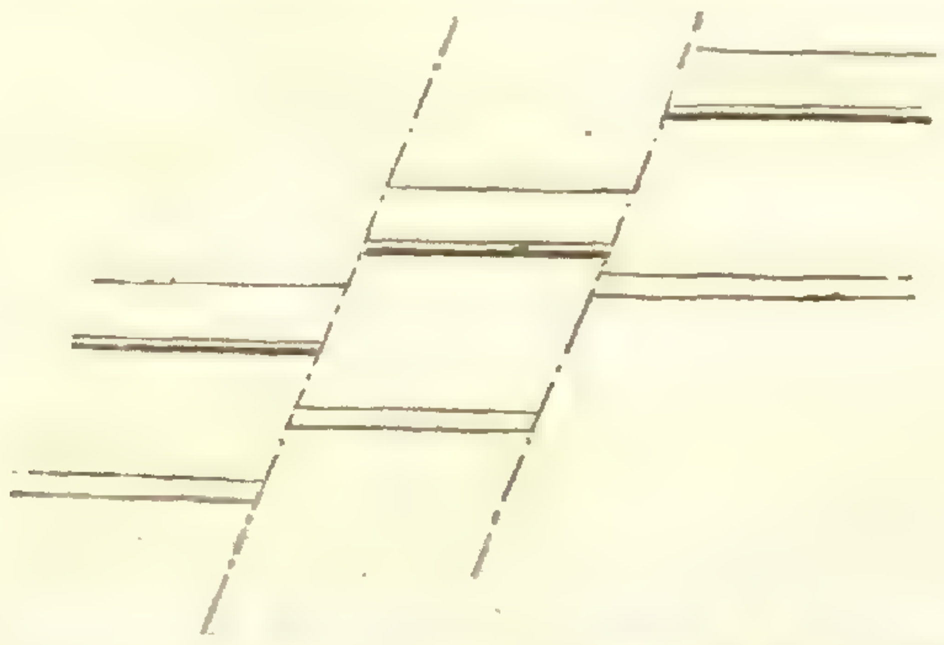
the lagoon and the mountains, I observed the edges of argillaceous strata in thin, slaty beds. These were soft, and not unlike those seen north of Salt creek in November. Still higher up the slope, and before the hill at the valley of the creek was reached, another outcrop was found. This was, however, composed of sandstone; the strata dipping westwardly, and showing thick beds. They did not stand out much above the surface, and were much obscured by a wash of gravel and sand. They were light-colored and probably Tertiary.

The approach to Carrizo creek over the long and gradual slope affords a good view of the mountains which bound the Desert on the west, and separate it from the coast slopes near San Diego. These mountains are the continuation of the same ranges which were constantly seen on the right hand during the passage of the Desert southwards from the San Bernardino Pass, and are portions of the great chain extending throughout the peninsula of California. The ridges at Carrizo creek are peculiarly barren and forbidding in their appearance, and, being without soil, are exceedingly rough and rugged.

Mountains of this character border both sides of the valley of Carrizo creek, but do not reach the vicinity of the road, so that they could not be readily examined. They, however, appeared to be composed of granitic and gneissose rocks, similar to those found in the ridges further north. Some of the ridges were very dark-colored, or nearly black, and may be erupted rocks, more recent than the gneiss.

The hill, at the upper edge of the slope by which the valley of the creek is reached, has already been noticed. When standing on this hill, and looking westward between the ranges of mountains, it becomes evident that the wide valley is occupied by nearly horizontal sedimentary strata, through which the creek has cut its way. It has excavated a wide and deep channel, cutting away and carrying out upon the margin of the Desert a large portion of the materials that once filled the valley to a much higher level than the present bed of the creek. This denuding action has left vertical walls at various places on each side of the stream, in which the horizontal layers of the sediments are exposed; and wherever side streams have entered the valley, other channels are formed, and isolated hills, with flat tops, are left standing, as if to indicate the former level of the surface. The exposed edges of the strata, so well seen in the natural sections, were not all horizontal, but presented various degrees of inclination and direction of dip. This, of course, would result where slightly inclined strata are cut in different directions by the tortuous course of a stream. From the repeated observations of the dip, and their relation to the configuration of the valley, I was led to conclude that their general or prevailing direction was *from* the granite ranges on each side towards the centre of the valley. No inclination greater than 20° was observed. There were, however, indications of comparatively local disturbances in the lower part of the valley, near to the slope of the Desert, in which the

FAULTS IN SANDSTONE STRATA, CARRIZO CREEK.



inclinations were much greater. These were seen from a distance, on the south of the trail, and were not far from a ridge of dark-colored rocks, which, from its appearance, I suspected might

be intrusive, and probably the cause of the disturbance of the beds. Additional evidence of violent disturbances of the strata was found in the presence of many faults or fractures of the beds. The preceding figure represents two faults, of about four feet each, seen on the face of one of the vertical exposures of strata. They were, in all probability, produced during earthquakes.

Seams and layers of gypsum were abundant in the banks on the side of the hill as we descended to the dry bed of the creek; and by the decomposition and wearing down of the beds, this mineral has become detached, and lies distributed on the surface in thin, transparent plates and fibrous masses. Other banks, higher up the creek, also contained thin seams of gypsum, associated with layers of sand, containing a large amount of peroxide of iron.

The *cache* of barley and the fossils, which we had made when on our way to the Gila, was found undisturbed, and I left the trail to give the locality of the fossils a further examination. The hill is on the north side of the valley, and stands alone, having a flat top, and the sides partly covered with great blocks, which have fallen from the upper stratum. This stratum is over fifteen feet thick,[1] and is formed entirely of the fossil shells and their fragments, mingled with a little clay. These fossils were so firmly impacted together that it was difficult to detach a single shell.

They all had a dark-brown color, and appeared to be changed in composition or silicified, but consisted of carbonate of lime.[2]

The top of this hill presents a level surface not over one hundred feet in breadth. A thin stratum of drift-stones was lying upon it, all of them being very smooth and glistening, looking as if they had lain there for ages. Among them I found several masses of silicified wood, one of them so large that I was unable to bring it away; smaller specimens were, however, obtained. In these the grain of the wood was well preserved; and all the small knots, and the rings of annual growth, were remarkably distinct. One of the specimens, in which the rings were perfectly shown on the ends, appeared to have been flattened by pressure, so as to produce ellipticity in all the rings. The specimens picked up on the desert slope were of similar formation and color. Wherever these specimens have lain out upon the surface exposed to the continued action of the loose sand, they have become worn and polished, so that the grain of the former wood is more distinctly displayed, by which their beauty is greatly increased.

CARRIZO CREEK TO SAN DIEGO.

December 15.—*Carrizo Creek to Vallecito*, 21 *miles*.—The water of Carrizo creek does not appear at the surface for many miles west of the entrance to its valley from the Desert. The greater part of the valley is entirely dry and sandy, and almost as forbidding as the Desert. The monotony is broken by a clump of palm trees on the north of the trail, and a green bank from which springs issue, known as the "Palm Springs."

These were situated under a bank of argillaceous, sedimentary beds. The water rises at various places, and seems to saturate the ground so thoroughly for a space two or three hundred feet in diameter, that a hole dug in any part of it soon becomes filled. The water was sulphurous, and gave off a slight quantity of sulphuretted hydrogen gas. A slight efflorescence of nitre was seen on the surface of the ground around the pools. The water, however, was not

[1] I find this thickness recorded in my notes; but *five* feet more nearly agrees with my recollection of the locality.—1855.

[2] For a description of these shells, see Appendix, Article II.

so strongly charged with these ingredients as to be unpleasant to drink, especially after having used the stagnant and muddy water of the Desert. I found its temperature, under the shade of a palm tree, to be 60° ; air, 70°. Three or four palm trees, each about thirty feet high, are standing on the bank from which the springs issue. They are much injured by fire and the persevering attacks of emigrants, who have cut down many of the finest of the group, as if determined that the only trees that grace the sandy avenue to the Desert, and afford a cool shade for the springs, should be destroyed.

The *Maguey*, a species of Agave, or the "American aloe," grows abundantly in the sands along the dry bed of this part of the creek, and in some places it completely covers the ground for long distances. This plant sends up tall cylindrical stems to a height of ten to fifteen feet, bearing immense clusters of beautiful yellow flowers. These bunches are almost large enough to fill a flour-barrel ; one of them that I cut down was too heavy to be conveniently carried.

Numerous varieties of cactaceæ, from the opuntia and melocactus, or "Turk's Head," to the most slender and thorny species, grow abundantly among the plants of the Agave. These plants, together with the *Fouqueria, Dalea,* and the palm trees, give a peculiar character to the landscape.

The mountains on each side are entirely bald and free from soil. They present a most rugged and forbidding aspect, and reflect back into the valley the scorching rays of the sun, and keep off all the cooling breezes. The climate of the valley is thus exceedingly hot ; it is even more uncomfortable than the open Desert. The sun's rays seem to have peculiar power and effect ; and more animals die in this valley, after reaching the water, than on the open Desert.

Near to Vallecito, the valley grows narrow, and the ascent more rapid. The sedimentary strata are no longer seen, and the granitic rocks appear and form the high ridges on each side. These ridges are barren ; and by long weathering have become of a dark-brown and nearly black hue, and in some portions present various shades of a dull red.

December 16.—*Vallecito to San Felipe*, 18 *miles.*—Vallecito is the first place where grass and vegetation greet the eyes of the traveller who has crossed the dreary Desert. It is a narrow valley between the granite ridges, and is well supplied with springs that are surrounded with grass and willows. These springs furnish good water, slightly impregnated with sulphuretted hydrogen and alkaline salts. Nearly opposite the camping-ground the granite is gneissoidal and slaty ; but it passes into the more compact and hard variety within a short distance. The whole is traversed by feldspathic veins.

The ridges on the right of Vallecito appear to have a distinct trend to the east of north—nearly N. 45° E.—while those on the left bear off to the west, or N. 11° W. These two systems of trends appear well developed, and give rise to transverse ridges, which, by their intersection, enclose a series of quadrangular valleys or basins. There are several of these enclosed spaces between Vallecito and the dividing ridge near Warner's ; and they give a peculiar character to the slope of the chain of mountains, breaking the ascent by a series of level spaces, separated by short but precipitous ridges. Thus, instead of a continuous gradual ascent through a long, narrow cañon or ravine, you pass in succession from one nearly level plain, enclosed by ridges, abruptly upwards to the level of another similar one, and so on, by a series of stair-like elevations, to the summit.

These enclosed spaces are generally nearly filled by accumulations of drift, and fine debris of granite, derived in part from the weathering of the surrounding ridges. This filling-in of a basin is generally so complete that the surface of the plain is often as high as the crest of

the ridge bounding it on the lower side. This gives the basin the appearance of having been filled to the brim during a period of submergence. In most cases the drainage waters of these spaces find exit through a narrow gorge or ravine, at a point lower than the general level or crest of the ridge, and the basin appears but partly filled. Thus, about four miles from Vallecito, the trail passes over a narrow ridge of granite, which separates between two valleys or basins. The abrupt ascent from the lower valley to the crest of this ridge, where crossed by the trail, was much greater than the descent on the other side to the level of the upper valley; showing a considerable difference of altitude between the two. These high valleys between the ridges, filled with wash and soil, may be regarded as the reproduction, on a small scale, of a characteristic peculiarity of the Great Basin, which, as has been shown, is filled in some places nearly to the crest of the bounding ranges.

The rocks between Vallecito and San Felipe, as seen along the trail, are mostly laminated and gneissoidal. About seven and a half miles from Vallecito, at the point where the trail makes an abrupt turn to the northeast, and winds in a narrow cut in the rocks, the laminated character is highly developed, and the laminæ are much flexed and contorted. The general trend is N. 30° to 45° W.; and the notes upon the dip indicate a synclinal flexure of considerable extent, at that point. Compact granite, exposing a granular and friable surface, was also noted, and numerous feldspathic veins traverse the mass of rock. Many of these were of great magnitude, and consisted essentially of feldspar, associated with quartz and tourmaline. Several veins of this kind showed distinctly on the side of a ridge adjoining the trail; they were remarkably regular and parallel, and were from ten to twenty feet thick, dipping southwest at angles of about 45°. At San Felipe camp, the prolongation of one of these feldspathic veins forms the base of the ridge on the north, and contains black tourmalines of gigantic dimensions. Their crystallization is, however, so imperfect that no good cabinet specimens could be obtained. They, however, present some peculiarities of crystallization.

No sedimentary rocks are visible between Vallecito and San Felipe; the valleys are narrow, and bounded by rugged ridges of granitic rocks alone. There is but little vegetation between the two points; the Agave and several varieties of cactus grow among the rocks, and several of the former were in flower.

San Felipe.—The valley of San Felipe is more extensive than that at Vallecito. It is also at a much greater elevation, and is bounded on one side by the summit-ridge of the sierra. It is well supplied with water by springs, and on the west side, by streams from the adjoining heights. Pine timber also grows on parts of the ridges towards the summit; in some of the sheltered ravines it is abundant, and of good size. Cotton-woods border one of the small streams for a short distance in the plain. The soil is good, and there is abundance of grass.

The stream, which flows from the springs in the lower part of the valley, finds its passage through the mountain, outwards to the desert, in a narrow, rugged cañon, on the north side, a little to the eastward of the Indian village. The rocks, as exposed along this natural section, consist of alternations of compact granite, with the laminated varieties. The trends are nearly north by the needle, and the planes of the beds or laminæ nearly vertical.

The rocks in the bed of the stream are partly covered by a remarkable incrustation, evidently deposited from the water. It was a foot thick in several places, and enclosed stems of reeds and small shells like those living in the brook. The occurrence of this calcareous crust on the rocks in a small brook, flowing towards the dry bed of the former lake, where such immense quantities of calcareous material once accumulated, is highly interesting. It, however, bears no resem-

blance to the incrustation on the rocks of the Desert, except in its chemical composition. We encamped at the springs, on the same ground where we had camped twice before. The night was very cold, and all the ridges were white with snow.

December 17.—*San Felipe to Santa Isabel*, 25 *miles*.—The ridges bordering the San Felipe valley are of granitic rocks. At and about the summit ridge, the highest point on the trail between the Pacific and the Colorado Desert, the granite is compact and syenitic, weathering into large, rounded, gray blocks, resembling Quincy syenite. Mica is one of the composing minerals; this with the hornblende and feldspar are in small crystals and evenly distributed, giving the mass a uniform texture. Oak trees grow luxuriantly on the soil formed by the decomposition of this gray granite, while the gneissoidal rocks, a little to the northward, appear almost barren. This is the region of trees and vegetation, and to the traveller presents a great contrast with the bald rocks and sandy desert between it and the Colorado.

Before reaching the summit, we left the road and ascended the rocky ridge on the right, finding it to consist of gneiss and mica slate, undoubtedly metamorphic rocks. From the top of this ridge a long and narrow valley could be seen extending up from the Desert towards *Agua Caliente*, (Warner's.)

SANTA ISABEL.

The ground at the summit of the pass was covered with snow about two inches deep, but the air was not very cold. We descended the western side of the mountain, and passed the ruins of Warner's adobe house, but instead of turning north to our former encampment in the valley, turned off to the south on the road to Santa Isabel. This road winds through a narrow and well-wooded valley adjoining the southern end of Warner's. The same compact granitic rock

seen at the summit, continues to extend on the left, and by its decomposition furnishes an excellent soil. We crossed many small streams, which furnish abundance of water to all parts of the valley, and permit the luxuriant growth of grass and oak trees. All the hills along the road were green with oaks[1] and chamizal, delighting the eye with their verdure after the pilgrimage on the Desert.

Santa Isabel is a beautiful valley among the mountains, well watered, and bordered by groves of oak and other timber. It has a varied and undulating surface, and a good granitic soil. Adobe buildings of great size were erected here in the time of the Padres, but are now partly in ruins. They were, however, in part, occupied as dwelling and storehouses, the valley being used as a cattle rancho. The surrounding hills were but sparsely wooded, but were covered with dried grass, showing the presence of a deep soil and abundant verdure during the spring and early summer.

December 18.—*Santa Isabel to San Pasqual*, 23.5 *miles.*—Gray, compact granite, similar to that at Agua Caliente, was found in the vicinity of Santa Isabel. About seven miles beyond, it became more syenitic in its character, and the surfaces that had been exposed to weathering, and to decomposition in the soil, exhibited small, brilliant crystals of green hornblende, standing out in relief, having resisted decomposition better than the feldspar, in which they were imbedded. Several miles beyond this point, on the side of the hill, the soil is colored red by a large amount of peroxide of iron, probably derived from the decomposition of pyrites. Fragments of quartz veins were also abundant. Large veins of feldspar and quartz were numerous along the road, and could be traced on the slopes of several ridges in the vicinity. Their white color showed distinctly through the green shrubs covering the hill-sides, and there appeared to be several nearly parallel veins. The first of these that was observed had a trend nearly northwest and southeast, magnetic. It appeared to be principally composed of coarsely crystalline feldspar, quartz, and tourmaline, with garnets, similar to the vein found on the other side of the divide at San Felipe. The feldspar in this vein, however, was more highly crystalline, and good crystals can be obtained there. The tourmaline, by its decomposition and abrasion, furnishes a large amount of black sand, which is distributed along the beds of the brooks and rivulets of the vicinity.

Just before reaching the lagoon, the direction of the veins was found to be more nearly east and west, several of them having a trend of only five degrees north and west, magnetic. Observation of the trend of the granite at that point gave the same result. These quartz veins and the red soil so highly charged with iron were regarded as indicating the presence of gold, but no examination or "prospect" could be made for it. We travelled very rapidly, and there was little opportunity for examination of the rocks beyond the trail.

After winding about the hills by a very crooked road, we reached the Rancho of Santa Maria, a fine open valley or plain, with good grass and water.

The observations made, under date of December 16, respecting the elevated valleys of the eastern slope of the mountains, will apply to this, the western side, also. The true character of the descent is not so distinctly visible as where the rocks and surface are almost entirely free from vegetation; but still it is evident, in descending towards the Pacific, that you pass successively from a high plain to a low one by a sudden descent, showing the existence of stair-like elevations or terraces, very different from the character of the slopes of the Sierra Nevada.

[1] Leaves of a species of oak growing most abundantly along the valley were collected, and have been submitted to Dr. Torrey. He regards the oak as very near *Q. imbricaria* of the Atlantic States.

The valleys of Santa Maria and San Pasqual, although near together, differ greatly in elevation. The road connecting the two places winds down long and almost precipitous hills. From the top of the principal hill an almost bird's-eye view was obtained of the valley of San Pasqual.

VALLEY OF SAN PASQUAL.[1]

It is small, and hemmed in on all sides by high hills or mountains. The plain was covered with green grass, and the windings of a stream were visible. A fine view was also presented of the mountains beyond, but there did not appear to be a unifornity in the trend of the ridges; they were exceedingly irregular.

We encamped in the valley on the bank of a brook, near a village of Indians. The valley appeared to be very damp, and probably is well watered throughout the year.

December 19.—*San Pasqual to San Diego,* 29 *miles.*—The country beyond San Pasqual is more open, and the granite ridges are less prominent and distinctly defined than about Santa Isabel and Warner's. Rounded hills of sedimentary orgin make their appearance, and contain rolled, water-worn boulders. These hills are of considerable altitude, and appeared to be principally formed of granitic sand and clays. From the summit of one of them the Pacific ocean was visible in the distance; and looking inland, towards the mountains we had been descending, the predominating direction of the minor ranges and ridges appeared to be nearly northwest and southeast. Some of the highest peaks and ridges were whitened with snow.

The rounded, sedimentary hills were free from large trees; but their slopes were already green

[1] By a mistake, either of the artist or the engraver, the ocean is too fully represented in the engraving, and appears too near. It is very distant, and, according to recollection, is scarcely visible from the hill.

with the young shoots of the wild oat springing up luxuriantly. It was evident that these hills were underlaid by granite at no great depth, as it frequently rose to view in low ridges.

A trap dyke, traversing the granite, was noted at a point about half-way between San Pasqual and the Mission, but I could not ascertain its direction with accuracy. A short distance beyond this dyke, a section of a low hill near the trail exposed a bed of conglomerate, six feet thick, dipping gently towards the southeast, at an angle of five degrees. It was full of rounded fragments, from one to three inches in diameter, all firmly cemented together, and underlaid by loose, sandy beds. The materials of the conglomerate were much water-worn, and it had the appearance of beach shingle.

A second exposure of trappean rock was crossed two or three miles westward of the first. The direction of this last intrusion appeared to be nearly the same as the prevailing trend of the granite ridges—northwest and southeast—and it appeared to form the last range of hills between the mountains and the Pacific. Westward from this point the country was entirely open, extending off towards the ocean in a broad, gently sloping plain, broken only by slight elevations around the bay of San Diego.

This wide slope flanks the foot-hills of the mountains for a long distance, both to the north and south of San Diego. Its rate of descent is so gradual that it seems like a plain, and appears to be unbroken by a single valley; but by travelling upon it, it is soon discovered that streams have cut their way below the surface, and excavated numerous deep, narrow channels and valleys, in one of which the Mission of San Diego is situated.

When the observer is in one of these excavated valleys, the view of the surrounding country is completely cut off by the continuous banks on each side. The surface of the slope is strewn with rounded pebbles and cobble-stones; and in some places these are thrown together in low heaps, like the accumulations upon a beach. These water-worn accumulations, together with the gentle and uniform slope of the broad plateau, give to it so much of the character and appearance of a shelving ocean beach, that, when an observer stands near its upper portions, on one of the banks of pebbles, and hears the dull sound of the distant surf, it is impossible to resist the conviction that it once broke among the pebbles at his feet.

There is a wide area of cultivable land about the Mission,[1] confined, however, to the valleys below the general level of the slope. There were few or no good exposures of the strata forming the slope, and no favorable natural section was seen. The strata are nearly horizontal, and probably Tertiary. While in camp, a mass of sandstone, filled with Tertiary fossils, was sent to me, but its precise locality could not be ascertained. It was probably taken from the adjoining hills, or picked up in the bed of one of the streams. On the way from the Mission (six miles inland from the bay) to "Old Town," or San Diego, I passed a slight exposure of the strata at the road-side, and found them to be composed chiefly of sand and argillaceous beds, some of them quite dark-brown, and nearly black with bitumen, indicating coal or lignite.

At Punta Loma, there is an exposure of strata made by the undermining action of the sea. It is probable that the strata are more recent than those of the slope, having a modern appearance, and not being firmly consolidated. They appear to dip gently towards the east or from the sea.

Before leaving San Diego, I collected many shells along the beach, and found a thick layer

[1] The Mission of San Diego was founded by the Padre Junipero Serra on the 16th of June, 1769, and became, with the Presidio, the first establishment of the Spaniards in New California, although the port of San Diego had been discovered a long time before. This Mission, which the Franciscans called the *Mother Mission*, is seventeen leagues north of San Miguel, the most northern Mission in Old California, and fourteen from the Mission of *San Luis Rey de Francia*.

of large and small shells near the top of one of the banks bordering the beach, and about twenty feet above the water. These may have been taken there by men or birds, but were imbedded in the soil, and looked like the remains of an old beach. An immense quantity of kelp is thrown

SAN DIEGO FROM THE BAY.

up on the clean, sandy beach by the waves, and forms a beautiful object when spread out to its full length. The only hills adjoining the bay are those of Punta Loma, and thus no sections of the strata were obtained. All the low banks were sandy.

SAN DIEGO TO SAN FRANCISCO.

December 23.—*San Diego to San Pedro.*—We left San Diego for San Francisco in the steamer Southerner in the afternoon and reached San Pedro the next morning. A high bank or bluff, of nearly horizontal strata, was seen to overhang the beach; and, on landing, it was found to be composed of argillaceous beds and sandstone, together with shales. The bank was highest to the right of the landing, and appeared to be from forty to sixty feet or more in height. It was nearly vertical; and, at high tide, the surf must reach its very foot. One of the beds near the base was very dark-colored—a greenish-black, or dark olive-green—and was evidently bituminous, giving off the odor readily when struck by the hammer. Higher in the series, the strata were lighter in color, but were much stained with peroxide of iron distributed through the earth and aggregated into nodules or concretions, which, at many places, protruded from the vertical bank. At the base of the bluff, and on the sand of the beach, a great number of loose tabular blocks of calcareous sandstone—three, four, and even six or eight feet across—showed the presence of a hard stratum in the vicinity, and it was believed to be near the top of the series, although not made evident by overhanging tables. These blocks were very hard, and not rapidly worn away by the surf. The flat surfaces were marked by sun-cracks, as if they had been exposed to the sun and air while in a soft and unconsolidated state.

A gentle flexure in the lines of stratification of these strata, as exposed in the bank, showed that they had been subjected to disturbance by the injection of igneous rocks or otherwise At the point, the dip was nearly five degrees, and the trend of the flexure, apparently, north 50° west.

Still further to the right the bank became lower, and the beach more broad. Other and apparently more modern accumulations took the place of the high bluff, and were found to contain vast quantities of marine shells in a layer about thirty feet above the tide-level. The bank presented the following succession of layers, from the top downwards:

1. Dark soil, containing fragments of shells	4 feet.
2. Coarse sand, with shells and beach-shingle at the base	6 "
3. Sea-sand, in layers, with seams of broken shells	20 "

At the base of No. 2 there was a layer of pebbles and masses of a calcareous and argillaceous

rock, perforated in every direction by boring-shells, which were still remaining in their cells, one or more shells being often found in the same cavity. The layer of fossils consisted, in great part, of fragments, evidently the debris and ruin of a beach. A great number of beautiful specimens were, however, obtained before the time for returning to the steamer arrived.

In passing back along the beach, it was observed that great numbers of these fossils had been broken out by the waves, and strewn along the beach among the recent shells. They could, however, be distinguished by their color, but did not appear to differ much in their forms. Under the high bluffs, I found many rounded masses of rock as black as ebony, and very smooth and light, and yet presenting very fine lines of stratification, as numerous and as thin as the leaves of a book. These were at first thought to be a peculiar *coal*, but the fracture showed them to be very hard and vitreous. They had the lustre of an impure resin, or hard tar. On drying, the surface became *white*, the fresh fractures remaining black, or a dark greenish-black. (Nos. 155 and 156 of the Catalogue.) A fragment of sandstone, traversed by seams or veins of clear bitumen, was also found.

Numerous species of living shells were collected ; they were very abundant on the beach and rocks at low tide.

The surface of the country is gently rolling, or nearly a plain, and there are no trees. A warehouse at the landing and two or three tenements were the only evidences of inhabitants. The harbor is very open ; but a limited space could be protected by a breakwater.

December 24.—*Santa Barbara.*—The mountains back of this place rise to a great height, and appear to extend nearly east and west. A narrow and abrupt slope to the sea is the site of the town. Trees were observed, and the Mission buildings presented a fine appearance on the high ground back of the town, which is near to the beach. There being no wharf, freight was landed through the surf, being taken from the boats on the backs of the men. Dr. Heerman, who went on shore, found a bank similar to that at San Pedro, and obtained several fossils, among them a gigantic "boat shell," or *Crepidula.* The mountains at this part of the coast are so near the sea, and so rugged, as to appear almost impracticable for a railroad.

December 25.—*San Luis Obispo and Monterey.*—We stopped for a few moments only at San Luis Obispo, and reached and left Monterey in the night, so that no observations on the rocks of these two places could be made. Arrived at San Francisco on the afternoon of the 26th of December.

II.

GEOLOGY OF PORTIONS OF THE ROUTE.

CHAPTER XI.

OBSERVATIONS ON THE OROGRAPHY AND GENERAL FEATURES OF RELIEF OF THE MIDDLE AND SOUTHERN PORTIONS OF CALIFORNIA.

GRANDEUR OF THE MOUNTAINS AND PLAINS.—SIERRA NEVADA AND ITS PROLONGATIONS SOUTHWARD.—BERNARDINO SIERRA.—PENINSULA SIERRA.—HIGH VALLEYS AND TABLE-LANDS OF THE NORTHERN PORTION OF THE SIERRA NEVADA.—TREND OF THE SIERRA.—SOUTHWEST AND NOTHEAST TREND AT THE SOUTHERN END.—ELEVATION OF THE CHAIN.—PASSES.—SOUTHERN LIMIT OF PERPETUAL SNOW.—BERNARDINO SIERRA.—EXTENT AND POSITION.—TREND.—THE BOUNDARY OF THE GREAT BASIN ON THE SOUTH.—GEOLOGICAL RELATIONS TO THE SIERRA NEVADA.—SUDDEN CHANGE IN THE TREND OF THE COAST AT POINT CONCEPTION.—SLOPE TO THE SEA.—DIFFERENCE OF ALTITUDE BETWEEN THE COAST SLOPE AND THE GREAT BASIN.—ELEVATION OF THE CHAIN AND PASSES.—FORMERLY CALLED SIERRA MADRE.—PENINSULA SIERRA.—EXTENT.—TREND.—GENERAL ELEVATION.—SHARP AND RUGGED OUTLINE.—COMPOSITE CHARACTER.—COAST MOUNTAINS.—PARALLEL RANGES AND VALLEYS.—OVERLAPPING OF THE RANGES.—SUBMERGED RANGES INDICATED BY THE LINES OF ISLANDS.—AVERAGE ELEVATION.—RANGES BETWEEN SAN FRANCISCO AND THE SAN JOAQUIN.—MOUNT DIABLO.—CLEFT OR BREAK IN THE WHOLE CHAIN.—GOLDEN GATE.—VALLEY OF THE SALINAS.—VALLEY OF THE BAY OF SAN FRANCISCO.—MOUNT DIABLO AND LIVERMORE'S VALLEY.—MOUNTAINS OF THE GREAT BASIN AND DESERT.—ISOLATED CHARACTER.—SLOPES.—PAI UTE RANGE.—DESERT RANGE.—PLAINS AND VALLEYS.—GREAT VALLEY OF CALIFORNIA.—RIVERS.—TULARE LAKES.—COLORADO DESERT.—EXTENT OF THE PLAIN.—ELEVATION.—ABSENCE OF RIVERS.—TREND.—ELEVATION COMPARED WITH THE COAST SLOPES AND THE GREAT BASIN.

That portion of the continent within the limits of the State of California presents a greater variety in the relief of its surface, and in its climate and vegetable productions, than any other portion of equal area. The lofty chains of mountains, towering into the regions of perpetual snow, are perhaps not more striking and peculiar than the broad, plain-like valleys which lie at their base, and separate the principal ranges.

The prominent orographic features are developed on a grand scale, and with such simple relations that a conception of them is readily formed. The chief range—the Sierra Nevada—rises like a great wall of separation between the State and the elevated semi-desert region of the Great Basin, and extends from the northern boundary as far south as the parallel of 35°. Parallel with this, and extending over a similar distance, we find the Coast Mountains; the two systems of ranges being separated by the broad plains of the Sacramento, San Joaquin, and the Tulares, but uniting in latitude 35 degrees; thus terminating the extended, interior valleys on the south.

South of this point of junction of the Sierra Nevada with the Coast Mountains, there is but one prominent range of mountains separating the coast-slope from the Great Basin and desert plains of the interior. Its direction is also different from either the Sierra Nevada or Coast Mountains, being nearly transverse to them, extending a few degrees south of east for more than 100 miles to the peak of San Bernardino. This is described in the notes as the *transverse chain*, the *Bernardino Mountains, or Bernardino Sierra.*[1]

The peak of San Bernardino is separated from a high mountain south of it—San Gorgoño—by a considerable break or gap, known as the pass of San Gorgoño or San Bernardino. From this pass, southwards, the mountains form a continuous line throughout the peninsula of Lower

[1] See Chapter VI, p. 55.

California to its extremity at Cape St. Lucas. This line of elevation will be described as the *Peninsula Sierra.*

In addition to the lines of elevation which have been enumerated, there are others of less extent in the Great Basin, and separating it from the Colorado river. Ranges are also found between the Peninsula Mountains and the Colorado; but all of these are only the southern extremities or prolongations of ranges which reach their greatest development beyond the limits of the State. The principal mountains of the State may thus be described under five groups or divisions—the Sierra Nevada, Bernardino Sierra, Peninsula Sierra, Coast Mountains, and Great Basin Mountains.

SIERRA NEVADA.

The explorations of the northern portion of the Sierra Nevada have shown that it is formed of many and nearly parallel ranges, enclosing elevated table-lands and valleys, precisely as in the Great Basin. There is no one predominant ridge or range towering high above the rest, thus forming a single and well-defined summit-line; but the ranges become gradually merged into the elevated region of the Great Basin. Very little is yet known of the central portions of the Sierra, but all the observations which have been made show that it is similarly formed. The results of the survey, from Walker's Pass southward, confirm those made at the north—establishing the existence of a series of elevated valleys or basins between ridges of nearly equal elevation.

The general direction of the ranges composing the Sierra, from the sources of the Sacramento southward to the headwaters of the forks of the American river, is north and south, or north a few degrees west. South of this point, or nearly east from San Francisco, there is a deflection of the chain to the east, so that its direction becomes northwest and southeast. Still further south, the line is more nearly meridional, and from latitude 36°, or at the sources of Posuncula river, near Walker's Pass, the chain curves towards the *southwest* to its termination at the Tejon near the parallel of 35°. This curvature towards the southwest is the only known instance of a northeast and southwest trend in any considerable part of the mountains of California. It is, however, probable that this direction is due in part to the overlapping of ridges which have nearly a meridional direction.

The pass called the *Cañada de las Uvas* may be regarded as the extreme southern limit of the Sierra, this being the line of division between it and the Coast Mountains and Bernardino Sierra. The whole length of the chain, measured from this point to its northern end near to the boundary, is about six hundred miles, reaching from latitude 42° to 35°. It is not yet possible to determine, even approximately, the average altitude of this chain, for but very few observations on the height of the peaks have yet been made. The elevation of many of the passes has, however, been determined, and estimates made of the heights of the adjoining peaks; but these have generally been in the most depressed parts of the chain, where it was most accessible and easily traversed. According to Captain Beckwith, the plateau, or broad plains, on the flattened crest of the Sierra, near the Madelin Pass, have an elevation of about 5,000 feet, and a width of twenty miles; while the adjoining ridges on each side rise from 500 to 3,000 feet higher.

The observations of Messrs. Day and Goddard, of California, who have explored routes for a wagon-road near the central portions of the Sierra Nevada, show that the average elevation of the passes is not less than 7,000 feet.[1]

[1] Report of George H. Goddard, esq., in report of Surveyor General of California, 1856.

The chain retains a great elevation even south of latitude 37°, lofty snow-covered peaks being visible from the Tulare plains, and the outline being much broken and serrated. South of 36°, however, the altitude decreases, until at the Tejon the highest points are not over 7,500 feet above the sea; and the height of the passes, according to the determinations of the Survey, range from 4,000 to 5,300 feet. The elevations of the passes in the chain, so far as known, are exhibited in the table:

ELEVATION OF PASSES IN THE SIERRA NEVADA.

Name of pass.	Latitude.	Longitude.	Altitude.	Authority.
	° ′ ″	° ′ ″		
Madelin Pass	40 44 12		5,667	Beckwith.
Plateau			5,420	"
Second summit of Madelin Pass			5,596	"
Noble's Pass			6,074	"
Carson Pass	38 42 15	119 56 41	7,972	Goddard.
Luther's Pass			7,185	"
Daggett's Pass			6,824	"
Breocia Pass, near the middle fork of the Stanislaus			10,150	"
Johnson's Pass			6,752	"
Walker's Pass	35 39 00		5,306	Williamson.
Humpahyamup	35 33 38		5,351	"
Taheechaypah Pass	35 07 28		4,008	"
Tejon	35 02 47	118 43 31	5,364	"
Cañada de las Uvas	34 54 40		4,315	"

The elevation of the peak of Shasta is estimated as not less than 18,000 feet, and several peaks or ridges near the sources of the American, the Calaveras, and Stanislaus rivers are, probably, over 12,000.

Summits, covered with perpetual snow, are visible in favorable conditions of the air from the valley of the Sacramento, and appear but little nearer to the observer when he has travelled thirty or forty miles towards them, and ascended 2,500 or 3,000 feet. They are also visible from the San Joaquin plains, and present a beautiful appearance from the vicinity of the Four Creeks, on the Tulare plains. The snow-covered peaks and ridges form a long line, and, although distant, stand out in full view, and glitter in the sun's rays, or become tinted with red and purple at sunset. The chain ceases to merit the name of *snowy* nearly under the parallel of 36°; for, from this point, southward, the snow does not remain through the year. This point is in the vicinity of Walker's Pass, and is just north of the sources of Posuncula river. Between Walker's Pass and the Tejon the elevated valleys are well watered by streams, the soil is deep and good, and grass grows luxuriantly. There are, also, extensive groves of beautiful oaks, covering parts of the surface so as to form natural parks.

BERNARDINO MOUNTAINS, OR BERNARDINO SIERRA.

The ranges which compose the Bernardino Sierra are nearly transverse to the southern end of the Sierra Nevada, and extend from that point, a few degrees south of east, to the high, and well-known peak of San Bernardino, in longitude 117°.

The mountains having this transverse direction do not, however, end abruptly at the end of the Sierra Nevada, but preserve their direction beyond it, towards Point Conception on the coast, thus crossing the southern ends of the Coast Mountains also. The chain is rendered distinct from the Coast Mountains, not only by its direction, but by its geological structure, it being granitic and metamorphic, while the ranges of the Coast Mountains are chiefly of more modern and sedimentary strata. The limits of the Bernardino Sierra, on the west, may thus be considered to be at the termination of the high granitic ridges north of Santa Barbara, although, topographically, it is believed to be prolonged nearly to Point Conception. As, however, the topography of that region is but little known, the precise limits of the chain cannot be assigned, its relations to the terminal ranges of the Coast Mountains not being determined. The whole length of the chain from San Bernardino to its eastern end is between 170 and 200 miles, it being about 200 from Point Conception to the mountain. The length, along the northern or interior slope of the chain, from the end of the Sierra Nevada, eastward, is about 120 miles.

The mean or average direction may be considered as west 20° north, east 20° south; this being the direction of that part of the chain between San Bernardino Mountain and the end of the Sierra Nevada.

These mountains, east of the Sierra Nevada, are the only wall of separation between the elevated surface of the Great Basin and the sea, being, in fact, the southern rim of the Basin, and holding the same relation to it as the Sierra Nevada on the west. There is no great range or chain of heights between the chain and the Pacific corresponding to the Coast Mountains west of the Sierra Nevada. Low hills and a line of intrusive rocks are found, but they do not form a prominent topographical feature, or exert a marked influence on the climate. The sudden and remarkable change in the direction of the coast-line found at Point Conception is produced by this line of mountains. From a general northwest and southeast trend of the coast, parallel with the Sierra Nevada and Coast Mountains north of Point Conception, the direction becomes, on the south, nearly east and west, conforming very nearly to the base of the chain. The slopes of the mountains thus face the south, and the climate of the region differs very greatly from that north of the cape. In the vicinity of Santa Barbara, a range rises directly up from the water, and is not flanked by a slope; the shore-line is thus very clearly defined, and is nearly east and west in its direction. East of San Buenaventura, on the coast, the shore-line is no longer coincident with the base of the ranges, but trends more to the south, the base of the mountains continuing inland with nearly the same direction, leaving a broad slope between it and the beach.

The difference of altitude between the upper margin of this seaward slope and the margin of the slope of the Great Basin on the other side of the chain is worthy of special notice. It is a marked feature in the relief of the region. The foot of the ranges at several points on the south side varies from 1,000 to 1,500 feet in elevation, while a corresponding line on the side of the Great Basin has a mean elevation of 3,000 feet or more.

The mean elevation of the chain can be only approximately given, but the numerous surveys of the passes by the Expedition, and the reconnoissance along the northern slope, permit a close estimate to be made. The number of passes show the broken character of the chain, and the plotted results of the Survey exhibit an overlapping position of the ranges. The passes, with scarcely an exception, are oblique to the general trend of the chain, and are coincident with some marked geological feature, forming long valleys extending between the ranges. The

order of succession of the passes from the Cañada de las Uvas eastward to San Bernardino, together with their elevation above the sea, as determined by the survey, is as follows:

Cajon de Tenoco	4,256.
San Francisquito	3,445.
Williamson's (New Pass)	3,164.
Cajon	4,676.

These are mentioned in the order of their succession from west to east, and all of them lead from the Great Basin to the coast slope, the Cajon de Tenoco leading southward from the summit of the Cañada de las Uvas. The elevations of the summits are but little above the margin of the Basin slope, and the line of water-shed is nearly coincident with it. This is strikingly exhibited at the Cajon Pass, where the summit is formed of the unconsolidated materials of the Basin slope. West of the Cañada de las Uvas, or the Cajon de Tenoco, the chain has been but little explored. The mountains back of Santa Barbara are high and rugged. A break further west, called the Gaviota Pass, is said to be only 600 feet above the sea.[1]

The most elevated point in the chain is the peak of San Bernardino, in longitude 116° 45′. Its elevation is variously estimated at from 7,000 to 9,000 feet, but is probably not over 8,500. The summit is bald and rounded, and probably composed of granite. It has a grey color, and is covered with snow for the greater part of the year. This mountain is a noted landmark, and has been used as an initial point by the United States land survey. Other high ridges in the vicinity of the Cajon are probably not over 2,000 or 2,500 feet higher than the summit of the pass, and thus about 7,000 feet in elevation. The average elevation of the chain is probably about 6,000 feet.

The altitude of this chain, as well as its geological structure, indicates that it should be regarded as the southern prolongation of the great chain of the Sierra Nevada, rather than of the Coast Mountains. It is entirely different from the latter, topographically, in its direction, and in its geological structure. The Coast Mountains find their equivalents in the minor ranges nearer the coast—the San Fernando range and others, composed of uplifted Tertiary strata and of intrusive rocks or dykes.

Subordinate parts of the Bernardino Sierra are known under local names, as, for example: Qui-quai-mungo range, San Gabriel range, San Fernando range, and Santa Inez range. The whole chain, or a portion of it, was formerly called *Sierra Madre* by the Padres—probably from the fact that the Sierra Nevada, the Coast Mountains, and other ranges seem to spring from it. The name, however, appears to have been applied in the most general manner, and has not passed into use; as, also, it is now applied to the principal range extending from the table-land of Mexico, or Anahuac, into the territories of the United States, it is not desirable to retain it for the chain which has been described. The name *Bernardino Sierra*[2] is therefore proposed.

PENINSULA SIERRA.

A great change in the direction of the mountains is found at the eastern extremity of the Bernardino Sierra. From the general east and west direction, the trend becomes nearly north and south, so that a nearly rectangular intersection of the chains is formed. The ranges of the Ber-

[1] On the authority of Professor James Nooney, of California, from barometrical observations made in 1849.

[2] The Spanish word *Sierra*, applied to mountains, denotes a range or chain with a serrated outline like the teeth of a saw; or, as commonly used, a chain of mountains or pointed summits. As the word has become Anglicized in New Mexico and California, where it is in constant use, I adopt it as the equivalent of the expression, *chain of mountains*.

nardino Sierra are not, however, bent and connected with those having the meridional direction, but are separated by a wide break, or pass of low elevation, leading from the coast slope to the interior. This is known as the Pass of San Gorgóño or San Bernardino, and is directly south of the peak of San Bernardino, separating it from the high peak of San Gorgoño on the south.

From the peak of San Gorgoño southward there is a continuous chain of ranges and ridges separating between the coast slope and the interior plain or valley of the Colorado desert, and further south, between the waters of the gulf and the Pacific, as far as the extremity of the Peninsula at Cape St. Lucas. The valley of the gulf reaches, as will presently be shown, as far north or northwest as the base of San Bernardino Mountain, and, in fact, the chain divides the valley of the gulf from the Pacific, being peninsular in its character throughout. It may, therefore, with propriety, be called the *Peninsula Sierra* or *Peninsula Mountains.* These and the adjoining mountains are indicated on the map of Major Emory as the *Cordilleras of California;* but the name is evidently used in its most extended sense, and not intended to be specific.

The northern part of the chain—that portion north of the boundary—is more nearly north and south in its direction than the part south of the boundary line, forming the main part of the peninsula. The position of the ranges at the northern end is such that, when viewed from the valley of San Bernardino, they appear nearly due north and south, and apparently abut against the Bernardino Sierra at right angles. The general axis of the northern end of the chain has, however, the trend north 25° west.

The average elevation of the Peninsula Sierra from San Gorgoño to the boundary is probably less than that of the Bernardino Sierra. San Gorgoño is the highest peak, and is probably 7,000 feet in elevation. The ridges near Warner's Pass are probably 5,000 feet in elevation; and the pass—the principal one of the chain south of the San Bernardino Pass—is 3,780 feet. A pass near the boundary has about the same elevation.

The crest of this chain is much broken, and the sky outline, as seen from the Colorado desert, is peculiarly sharp and rugged, simulating the teeth of a saw, thus deserving the expressive word *sierra.* There are many ranges and ridges, trending generally in northwest and southeast lines, oblique to the axis of the chain. This composite character and overlapping of the ridges is shown in the region of Warner's Pass, where a line of elevated valleys or slight basins separate the ridges, and trend parallel with them to the northwest. Other and similar valleys are known to exist north of these, but they have not been explored. The interior slopes of the mountains are rocky and barren, while the seaward sides are covered with grass and trees.

COAST MOUNTAINS.

In California the term *Coast Mountains* is generally understood to refer to the several ranges of mountains lying west of the Sierra Nevada, extending from Oregon to Point Conception, and forming the barrier between the long, interior valleys of the Sacramento and San Joaquin and the Pacific ocean. The name will be used in the same sense in the following descriptions. The mountains lying between the Sierra Nevada and the coast, when first seen from the valley of the Sacramento, appeared to consist of but one range or crest along the coast, and therefore received the name of *Coast Range.* Exploration has, however, shown that there are many and parallel ranges rising between the Sacramento and San Joaquin plains and the Pacific, and thus the name *Coast Range* has gradually given place to the more comprehensive and general one of *Coast Mountains.*

In the latitude of San Francisco there are three prominent ranges: the first, or most western, bordering the Pacific, called the San Francisco and San Bruno range; the second, Central or Contra Costa range; and the third, Diablo range. These are separated by longitudinal valleys of considerable extent.

We also find long, parallel ranges with included valleys in the latitude of Monterey. Point Pinos, which extends out into the sea, and forms the bulwark of the bay of Monterey, is the end of a long and elevated range, formerly called the *Sierra de Santa Lucia.*[1] which extends southward, and forms the coast-line nearly to San Luis Obispo. This range is probably granitic, and forms a bold, rocky shore for nearly its entire length. This range is separated from another, further inland, by the long and extensive valley of the Salinas or San Buenaventura river. The second range appears to be the prolongation of the mountains forming the northeastern shore of the bay—the Santa Cruz range. It is crossed by the road from Monterey to San Francisco at a point near the mission of San Juan, and is there known as the *San Juan range;* further south it is sometimes called the *Gavilan* or *Salinas range.* A third or inner range forms the eastern side of the Benito valley, and divides it from the San Joaquin. The valley of the Salinas is about sixty miles in length, and near its northern extremity about twelve wide. The bay of Monterey may be considered as formed by the junction of this valley with the sea.

In the latitude of San Luis Obispo the same characteristic parallelism of ranges prevails. At that point they are bold and elevated, and the topography of the interior is as yet but little known. The ranges north of San Francisco are also parallel, and separated by valleys.

We have thus seen that the Coast Mountains do not form one, single, continuous ridge bordering the sea, but that they consist of many parallel ranges, enclosing long and extensive valleys. The breadth over which these ranges extend varies at different points. At San Francisco it is about 40 miles, at Monterey 60, and further south, between the Tulares and the coast, nearly 70 miles. The breadth is even greater towards the north—north of the bay of San Francisco.

The general direction of all the ranges between Sir Francis Drake's bay and Point Conception is northwest and southeast, being parallel with the trend of the Sierra Nevada, and coincident with the general trend of the coast-line, this, in fact, being determined by the mountains. Sudden bends or inflexions of the coast-line are found at several points, as, for example, the bay of Monterey, which occupies the space between the end of one range and the side of another, the outer range passing beneath the sea at Point Pinos, and thus leaving the valley of the Salinas open. This disposition of the ranges shows an overlapping character, which is found also at other points of the Coast Mountains. The ranges appear to be placed *en echelon,* and to overlap towards the northwest in an ascending order from south to north. This arrangement is visible on a good topographical map of the country, and may be seen, within a limited area, on the charts of the bay of San Francisco and San Pablo, where the inner ranges pass beyond and terminate north of the outer.

The groups of islands, ranged in lines parallel to the coast and the adjoining ranges of mountains, may be regarded as the culminating points or crests of submerged ranges. I have so considered them in recent observations on the hydrography of the coast, prepared for Professor A. D. Bache, of the United States Coast Survey.[2] It is probable that there are three marine ranges, although there may be but two. One is nearly east and west in its direction,

[1] So named by Vizcaino, December, 1602.—(See an extract from *Torquemada's Monarchia Indiana,* in Venega's History of California, ii, p. 282.)

[2] See Report of the Superintendent of the United States Coast Survey for 1855.

and is indicated by the islands of Anacapa, Santa Rosa, Santa Cruz, and San Miguel. It is nearly parallel with the Bernardino Sierra, and holds a relation to that chain similar to that of the Coast Mountains to the Sierra Nevada. If the whole region, with the bed of the ocean, were lifted up, so as to drain the valley now occupied by the channel of Santa Barbara, a valley would be formed similar in many respects to that between the Sierra and the Coast Mountains.

With regard to the general or average elevation of the Coast Mountains we are without sufficient data to form an accurate conclusion. Several determinations of altitude have been made in the vicinity of San Francisco, but the observations along the ranges south of that point are very few. Table Hill, north of the entrance to the bay, is 2,569 feet high, and there are many higher summits beyond. South of the entrance, the San Francisco or San Bruno range commences in hills of moderate elevation, but increases in altitude towards the south, until opposite the valley of San José the average elevation of the range is not less than 2,000 feet. There are many lofty ridges between San José and Santa Cruz.

Blue Mountain, a few miles southwest of the city, is 1,097 feet high, and another point a little farther south is 1,263. The Contra Costa range, opposite San Francisco, probably has the average elevation of 1,800 or 2,000 feet. One of the summits, nearly opposite the entrance of the bay, is reported to be 1,952 feet high.[1] This range forms the highlands on the east side of the bay, but does not rise abruptly from the shore, being flanked by a margin or gentle slope of alluvial origin, upon which the villages of Oakland, San Antonio, and Clifton are built. Further south, it is much broader and more valuable for agriculture.

The third, or Diablo range, extends southeasterly from Mount Diablo, bordering the broad valley of the San Joaquin. It is separated from the Central range by a long valley—a part of which is known as Livermore's; but nearly opposite the south end of the Bay of San Francisco the two ranges appear to unite in one. The average elevation of a part of this range is not so great as the Contra Costa or San Francisco range. It is composed of a series of hills with rounded outlines and a moderate elevation; but at the northern extremity, Mount Diablo rises with a bold and rugged outline to an altitude of 3,960 feet.[2] It is a majestic mountain and a prominent landmark, being visible from distant points in the Sacramento and San Joaquin valley, and from the ocean when approaching the entrance to the bay. It is also distinctly visible from the city of San Francisco, rising high above the crest of the Central or Contra Costa range. The low hills, which constitute a part of the range, bound Livermore's valley on the east, and are broken by several passes—one of which (Livermore's) was surveyed by the Expedition, and found to have an altitude of 686 feet.

The southerly prolongation of this range—beyond the point of unison with the Contra Costa or Central range—reaches a greater altitude, and is marked by several prominent peaks which have not been fully explored. Pacheco's peak, which is nearly opposite the headwaters of the San Joaquin, is reported to be 2,700 feet in elevation, and to be composed of volcanic rocks.[3]

The entrance to the Bay of San Francisco—the Golden Gate—together with the channel reaching to the valley of the Sacramento and San Joaquin, is one of the most remarkable breaks in a chain of mountains which is yet known. It is like a great cleft or fissure, and extends at right angles to the trends of the ranges. The ridges end abruptly on each side of the Golden Gate. Those on the north side, being undermined by the currents, present bold, vertical cliffs of rock, and thus increase the resemblance to a great cleft. The shores of the

[1] For these altitudes see charts of the Bay of San Francisco, by Cadwalader Ringold, commander U. S. navy, 1850.

[2] Report of Lieut. R. S. Williamson.—(Senate, 31st Cong., 1st sess., Ex. Doc. 47, p. 35.)

[3] J. B. Trask—verbal communication.

bay, and the channel eastward to the interior valleys, are broken by projecting headlands, the ends of ranges which exhibit an almost perfect parallelism, trending with the main lines of elevation in northwest and southeast lines. A series of parallel coves, or long bays, are formed by these promontories, and many of the ranges can be traced from one side of the break to the other, as at Benicia. The islands of Yerba Buena, Angel island, and others, will be seen to be in the line of trend of adjoining headlands.

The most extensive valley in the Coast Mountains is that of the Salinas river, reaching southward from the bay of Monterey between the Sierra Santa Lucia and the Gavilan or Salinas range. Its northern end forms a great part of the shore of the bay of Monterey, and it extends southwards for sixty miles, and is traversed by the Salinas. It forms one great plain, and in its lower portions is without the trough-like character common to the valleys which receive side-streams from the bordering mountains. Its area may be approximately stated as 400 square miles.

The three ranges in the latitude of San Francisco bound two principal valleys. The most extensive is that of the bay, occupied in its southern prolongation by the villages of Santa Clara and San José, and generally known, in its southern portion, as the valley of San José. It is of considerable extent, being over 60 miles in length from north to south ; its southern extremity connecting with the valley of the Pajaro river, which empties into the bay of Monterey.

The width of the valley between the bases of the mountains, at its widest part, a few miles south of San Francisco, is about 15 miles. The shores of the bay are low and alluvial, and where a river enters, they are deeply indented by long and crooked channels. At the southern end of the bay there is a wide area of low, marshy land, which is alternately covered and left bare by the tides. From this swampy tract the ground rises almost insensibly to the broad and plain-like expanse of the San José valley, remarkable alike for its delightful climate, the richness of the soil, and its adaptation to agriculture.

The second valley, or rather a series of valleys, lies between the Contra Costa and Diablo ranges, and is known in its different parts as Mount Diablo, Amidor's and Livermore's valley. The drainage of Mount Diablo Valley is northwards into Susuin Bay, and of Livermore's eastward, into the bay of San Francisco.

MOUNTAINS OF THE GREAT BASIN AND DESERT.

The mountains of that part of the Great Basin included within the limits of the State of California do not form continuous and well-defined ranges like those already described. They rise in broken and isolated ridges, having a general north and south direction, but distributed at intervals over the elevated surface of the Basin, and not characterized by the linear arrangement found to prevail further north. Exception must, however, be made for the eastern ridges and ranges of the Sierra Nevada, which, in the vicinity of Owens' lake and Walker's lake, trend in long lines, and become, in some cases, ranges of the Basin.

A linear disposition of the ranges is also found on the eastern border of the Basin, where they unite to form a line of mountains, called by Captain Whipple the Pai Ute range, separating the Basin from the valley of the Colorado. This line is continuous towards the north from the mountain of San Bernardino. The Mojave river flows along its western base until, finally, it sinks in one of the lowest valleys. When viewed from the surface of the Great Basin, the chain appears very much broken into ridges and isolated, conical peaks, and they are seen to be connected

by long slopes, which, by their intersection, produce elevated valleys or basins. It appears to be a combination of these ridges and included slopes which forms the eastern boundary of the Basin, rather than one or more prominent and well-defined ranges.

According to the observations of Captain Whipple, who crossed the mountains between the Colorado and the Soda Lake, at the end of the Mojave, the line of elevation consists of a combination of ridges and valleys, so that its surface is exceedingly irregular. The elevation of the summit at the point of crossing was found to be about 4,900 feet above the Colorado, and 5,300 feet above the sea.[1] The general elevation of the peaks does not much exceed this; they are probably not more than 600 feet higher. The barometrical observations of Captain Whipple show that the two slopes of the range are nearly alike in their inclination. The direction or trend of the whole range, or its general axis, at that point, is nearly north and south, or inclining slightly to the northeast; but it is very probable that most of the ridges are oblique to the general trend of the range, and, by their overlapping, produce the deflection of the main axis to the northeast, this being the direction of the line of water-shed between the Basin and the Colorado from that point northwards.

South of the Pai Ute range, and between the Colorado and the Peninsula Sierra, we find a succession of ridges, which bound or form the northeastern side of the Colorado Desert. When seen from the inland base of the Peninsula Sierra these ridges appear to form one continuous range, trending nearly northwest and southeast from the northern base of San Bernardino to the mouth of the Gila. In traversing the Desert, however, the mountains are found to rise in succession in long projecting ridges above the horizon, thus showing the broken or composite character of the range, and that the ridges overlap. This structure is more clearly visible from the extreme southwestern point of the range, a few miles northwest of Pilot Knob, near Fort Yuma, at the mouth of the Gila. It is most probable that the ridges are separated by long, narrow valleys, trending nearly northwest and southeast. The distance to which the ranges extend towards the north is not yet known, as the region lying between them and the Mojave river has not been explored. The existence of a broad, open plain in that direction has been reported, and this renders it most probable that the mountains form one line or range from the Gila to San Bernardino. They are so represented on the map. The same chain appears prolonged, southeast of the mouth of the Gila, into the Mexican State, Sonora. The ranges there have the same general trend, are in the same line, and form the first chain of mountains east of the shore of the Gulf, from which it is separated by a nearly level and desert-plain—the *Sonora Desert*. These ranges are all rocky, and, to all appearance, entirely barren. Their elevation, within the limits of California, probably does not exceed 3,000 feet.

The sky-outline of the mountains, north and northwest of Fort Yuma, is exceedingly varied and picturesque. In some places they rise in sharp peaks or pinnacles, with vertical sides like chimneys, and in others form domes, so regular in curvature that they seem like works of art.

PLAINS, VALLEYS, AND SLOPES.

The valleys of California may, for convenience of description, be grouped in four divisions: First, the low and broad valleys, which by their extent become plains; second, the mountain valleys, (generally elevated;) third, the elevated valleys of the Great Basin; fourth, the river valleys or cañons.

A brief, general description of the valleys of the Coast Mountains has already been presented,

[1] Report of Captain A. W. Whipple, U. S. Top. Engineers. See also the Report on the Geology of the route, p. 5.

and it is sufficient for the purposes of this chapter to give, in addition, a general description of the two principal valleys of the State—that between the Sierra Nevada and the Coast Mountains, and the valley of the Colorado Desert—with their relations to the elevated region of the Great Basin, and the broad coast slope south of the Bernardino Sierra.

The great valley or plain of California, lying between the Sierra Nevada and the Coast Mountains, is traversed in its lowest portions by the Sacramento and San Joaquin rivers, which, flowing from the north and the south, unite in the latitude of San Francisco, and empty into the bay. It, however, extends far southward of the sources of the San Joaquin, and includes the broad valley of the Tulare lakes, generally known as the Tulare Valley, which, although at some seasons without drainage to the sea, is, topographically, a part of the extended plains under consideration. The limits of the valley on the south are determined by the union of the Sierra Nevada and the Coast Mountains under the parallel of 35°, and on the north it extends beyond the parallel of 40°, near to the head waters of the Sacramento, or over five degrees of latitude, a distance of more than 350 miles. Its average breadth south of the mouth of the American river, in the Sacramento, is about fifty-five miles; it being fifty miles at the mouth of the Sacramento and San Joaquin, at the sources of the San Joaquin sixty miles, and across the Tulare lakes over sixty. Its whole area probably exceeds 15,000 square miles, which is greater than the united areas of the States of Massachusetts, Rhode Island, and Connecticut.

This broad area is unbroken by hills or sudden swells of the surface, and thus, being nearly level, becomes a vast plain—the vision in the direction of its length being bounded by the distant horizon alone. The broad and level expanse is made more evident and striking to the observer by the general absence of trees, and the arid and gravelly surface during the dry season.

The average elevation of these plains above the sea is not great. A large portion of the surface bordering the Sacramento and San Joaquin, near their mouths, is but little elevated above tide-water, and is overflowed during freshets. This portion is, however, properly the delta of those streams, and is an extended alluvial marsh, where rushes and grass grow luxuriantly. A low border of alluvium is also found along the principal rivers. From this level the surface rises gently and very uniformly towards the base of the mountains, reaching, in some places, an elevation of only two or three hundred feet at the foot-hills, or first sudden swells of the surface, at the base of the more rocky and higher ridges of the mountains. At other points towards the south end of the valley and, probably, also at the northern end, the upper part of the slope has a much greater altitude, and extends far up on the sides of the mountains. Thus, at the Tejon the lowest portion of the Tulare Valley at Kern Lake is 398 feet above tide, and the surface rises from this point very gradually towards the surrounding mountains, reaching, in a distance of about nineteen miles, an elevation of 1,900 feet at the entrance of the Tejon Pass, and 1,600 at the entrance of the Cañada de las Uvas.

The two great streams, the Sacramento and San Joaquin, follow the axis of the valley for the greater part of their course, and receive the waters of numerous tributaries, flowing nearly at right angles to them, and rising in the Sierra Nevada on the east. On the other side there are, however, but few streams from the Coast Mountains, and these are of slight extent or importance. Most of the rivers from the Sierra are liable to great floods or freshets, and thus vary in the volume of their water at different seasons. At the border of the great valley, where they emerge from the cañons of the mountains, their banks are high and steep, and generally terraced; lower down the stream, the banks become lower, the streams wider, and, in many in-

stances, they expand so as to break up into many shallow channels, and even to become entirely lost by evaporation or absorption in the sand and gravel of the plain. The San Joaquin rises in the heights of the Sierra, and flows westerly at right angles to the axis of the valley, like its tributaries, until it reaches the centre of the valley, and then flows northwest in the direction of its length.

South of the San Joaquin, there are several large streams flowing from the Sierra Nevada into the Tulare lakes. The lakes are broad, but shallow, sheets of water, with shelving shores, so that a slight increase of the volume of the water during the rainy season covers a large area of the surface. When the water is very high it is said to flow into the San Joaquin, thus connecting the two valleys by drainage.

The valley of the Colorado Desert is, in many respects, similar to the Tulare Plains, but is more heated, arid, and desert-like. It is properly the northern prolongation of the valley of the Gulf, reaching from its shores to the base of San Bernardino, and bounded on one side by the Peninsula Sierra, and on the other by the ranges extending from the Gila to the mountain of San Bernardino. Its length to the head of the Gulf is thus about 180 miles, and its average breadth about 50, giving for its area 9,000 square miles. Its southern portion, or nearly half the area, is beyond the southern boundary of the State, and within the limits of Lower California. The elevation of this broad, plain-like valley is very slight, and a portion of its surface is probably below the level of the sea. It thus constitutes an important feature of the relief of the surface of the State. It is without any rivers, and only one or two small streams reach its borders from the Pass of San Barnardino and the Peninsula Sierra. These are speedily absorbed in the sand or evaporated. During seasons of very high water in the Colorado there is an overflow, which, extending inland to the lower parts of the Desert, forms a stream called New River.

The trend of the longer axis of the plain or valley is nearly northwest and southeast, being parallel with the mountains on each side, and coincident with the direction of the plains of the Sacramento and San Joaquin. The elevation of this valley presents a striking contrast with that of the coast slope on the opposite side of the mountains at the same distance from the crest. There, the elevation of the slope is not less than 1,000 feet, while the surface of the Desert is but little above the sea, and, in some places, is below it. But the contrast is still more striking when we compare the elevation of the Desert with the general surface of the Great Basin, on the other side of San Bernardino, its average altitude being about 3,000 feet. Thus the conditions of elevation characterizing the opposite sides of the Bernardino Sierra are completely reversed in those of the Peninsula Sierra. In the former, the interior plains are most elevated ; in the latter, they are the lowest. San Bernardino is thus an interesting point in the physical geography of the State. It stands as a dividing pillar in the approaching angles of three broad areas of unequal elevation, and as dissimilar in their climate and productions.

T. Sinclair's lith. Phila.

CHAPTER XII.

GEOLOGY OF THE VICINITY OF SAN FRANCISCO.

Enumeration of the principal formations.—Granite north and south of the golden gate.—Geological map.—San Francisco sandstone.—Points at which it is exposed.—Section at Yerba Buena.—Sandstone and shales.—Decomposition of the rock.—Globular masses, the result of decomposition.—Color of the rock.—Lithological characters.—Remains of plants.—Strata under the city.—Resemblance to trap rock.—Point Lobos.—Angel island.—State's prison quarry.—Section of the strata.—Dislocation of a bed of the sandstone.—Marin island.—Benicia sandstone.—Navy point.—Conglomerate.—Section of the strata at Navy point.—Hard bluish-green masses.—Probable synchronism of the strata with those near San Francisco.—Extension of the strata southwards near mount Diablo.—Sandstone at New Almaden, San Juan, and north of the golden gate.—Bellingham bay sandstone probably the same.—Age of the formation.—Fossils.—Probable tertiary age.—Section from San Francisco to the Pacific.—Metamorphic sandstone.—Jaspery or prasoid characters.—Erupted rocks.—Granite.—Trap.—Serpentine.—Fort point.—Diallage or bronzite.—Globular character of the rock.—Strata imbedded in the serpentine.—Post tertiary and alluvial deposits.—Encroachments of the sea.—Drift or surface accumulations.—Sand dunes.—Beach on the Pacific side.—Happy valley.—Stratification and ripple marks.—Artesian wells at San Francisco and San Jose.

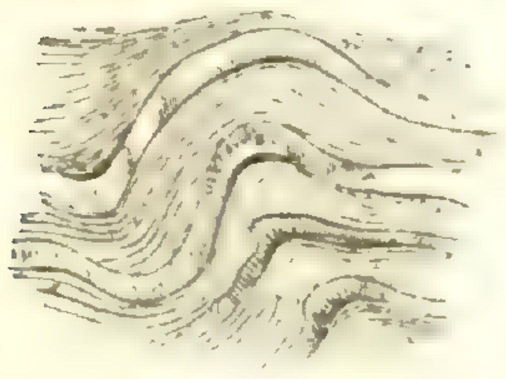
The principal rock formations of the vicinity of San Francisco are sandstones and shales, together with erupted trappean rocks and serpentine—all, probably, of comparatively recent geological age. Granite and the associate rocks were not seen near San Francisco, but they, probably, form the central portion of the San Francisco or San Bruno range, as far south as San José, or the mines of New Almaden, where a white crystalline limestone occurs. Granite is found in the Santa Cruz Mountains, and at Point Pinos, Monterey. It also outcrops on the coast north of the Golden Gate, forming the projecting headland called Punta de los Reyes, and the group of small islands, about twenty miles from the Golden Gate, known as the Farallones.

A small Geological Map of the vicinity of the entrance to the Bay of San Francisco is presented with this chapter, and will serve to show the geology of the headlands and the adjoining shores.[1] A fine-grained, compact sandstone, associated with shales, is the prevailing rock. It underlies the city of San Francisco, and is exposed along the shores of the bay, both north and south of the city, forming the principal promontories and points, and several islands. On entering the bay, from the Pacific, the rock is first seen at Point Lobos, the outer point, and again at North and Tonquin points. It borders a part, at least, of the Golden Gate, on the north, and forms the shores of Richardson's and Saucelito bays. Angel and Yerba Buena islands are also of this sandstone formation. In several places, hills and ridges, of over two or three hundred feet in elevation, are formed entirely of this rock, and the wearing action of the sea, at their base, and the break in the ranges forming the Golden Gate, have produced favorable sections where the characters of the strata may be studied. Availing myself, therefore, of these

[1] Since the printing of this report commenced, I have had the opportunity of seeing the volume on the Zoology of Captain Beechey's Voyage, in which I find some observations on the geology of the vicinity of San Francisco, prepared from the notes and collections of Lieutenant Belcher, by Professor Buckland. A map of the headlands, embracing about the same area as in the map accompanying this report, is also given in illustration. This is colored around the shores so as to indicate the several formations. Serpentine, sandstone, and jasper rock are represented.—*Zoology of Captain Beechey's Voyage to the Pacific and Behring's straits in* 1825,–'26,–'27, *and* 28. 4to, London, 1839.

natural exposures, and of the excavations made in quarrying, the strata were examined at the following places: City of San Francisco, Points Lobos, San José, Tonquin, and North, Yerba Buena island, Alcatrazes island, Angel island, Point San Quentin, north side of the Golden Gate, and along the shores of the Sancelito bay. Rocks, probably identical in age, were also examined at Benicia, New Almaden, and between San Juan and Monterey.

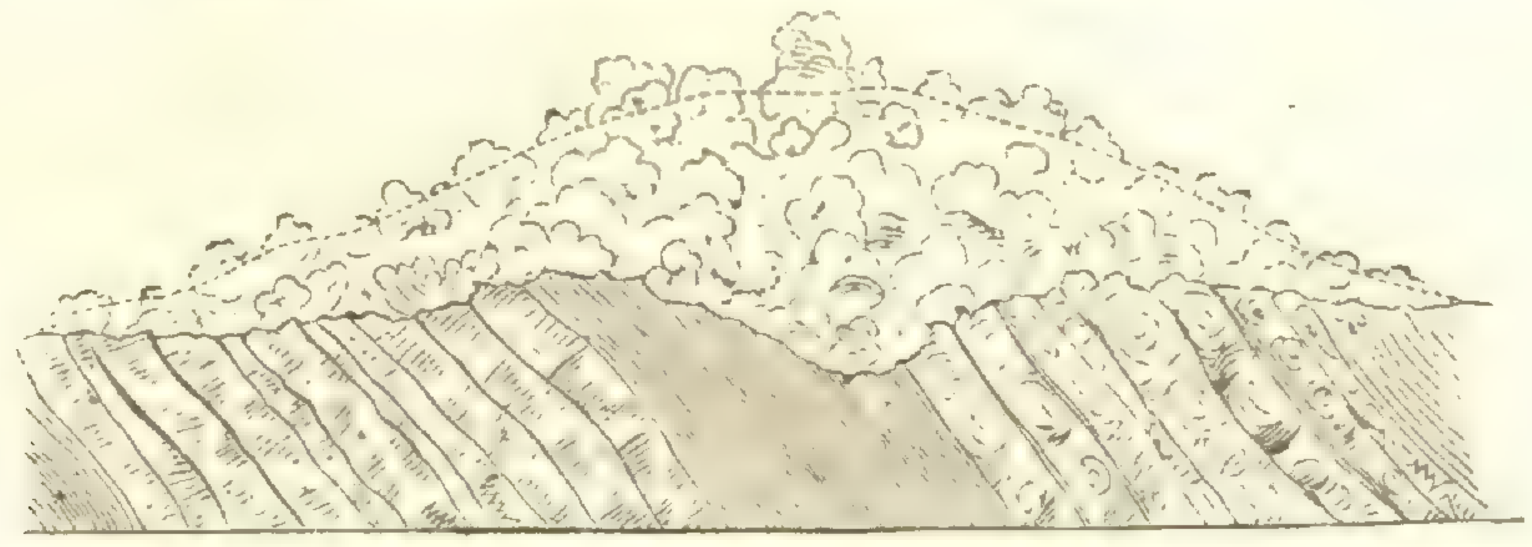
One of the best sections, where the lithological characters of a part of the formation are fully exposed, is at Yerba Buena, the island directly opposite San Francisco. This is composed



entirely of the sandstone and shale; the strata are laid bare by the action of the water around the base of the island, and form a bold rocky shore, which in many places appears to offer great resistance to the persistent denuding action of the waves and strong currents. On approaching the island from the west the evidences of stratification become visible, and the beds are seen to dip westward, toward the observer. There are also several places where the strata are bent and contorted, as in the figure.

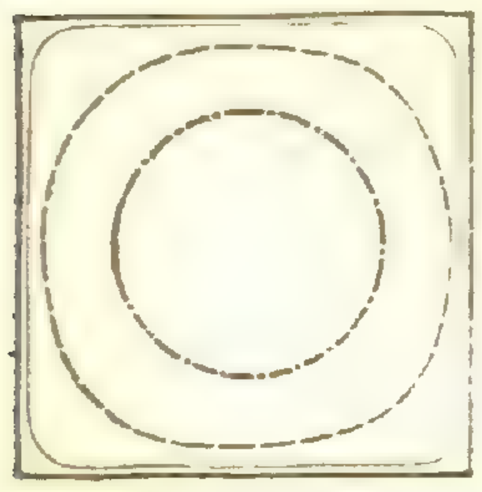
On the south end of the island a quarry has been opened. At this point the edges of the strata are distinctly exposed, and are seen to dip about 20 N. of E., at an angle of 45°. The position and general characters of the strata may be best exhibited by a short local section, the total thickness represented being about two hundred feet. The thicknesses of the compact beds

SECTION OF SANDSTONE AND SHALE, YERBA BUENA.



of sandstone vary from a few inches to six and eight feet; the layers alternate with beds of argillaceous slates and shales. All the weathered surfaces of this series of beds are of a rusty-brown or drab color, which extends throughout the rock to a depth of from ten to twenty feet, down to the limit of atmospheric influences. There are, however, parts of the upper beds that have not yet been reached and changed by decomposition; these parts are found in the condition of spherical or ellipsoidal masses, from which the weathered parts scale off in successive crusts. These nuclei have the appearance of great rounded boulders, and have accumulated in great numbers at the base of the cliff. They are of various sizes, but are smallest in the upper parts of the strata, near to the surface.

This spherical or globular condition does not appear to be the result of any peculiar arrangement of the material of the strata, a concretionary action, such as takes place in the igneous rocks, but is probably due to decomposition—the result of the absorption of infiltrating waters, charged with impurities. A solid and homogeneous cube of sandstone thus exposed, under conditions favorable for absorption of the water on all its sides, would decompose most rapidly on the angles, producing a succession of curved surfaces gradually approaching a sphere, as is represented in the figure.



These necessary conditions for the infiltration of water exist in the strata. Each layer of rock is divided into blocks of various sizes by joints, or cleavage planes, similar to those traversing

crystalline rocks; these are nearly vertical to the planes of stratification, and cut through all the beds. Seams are thus formed for the access of air and water.

The color of this sandstone is dark bluish-green, inclining to gray. It is exceedingly compact and tough, and does not break so easily as the fine-grained red sandstone of the Connecticut river and New Jersey quarries. Its texture varies but little in the different beds; the grain is close and even, and generally very fine.

The grains are chiefly silicious, and are mingled with those of finely triturated glassy feldspar and other minerals, the whole being apparently cemented together by fine particles, or probably, in part, by carbonate of lime. Nearly all of the specimens submitted to examination were found to be calcareous, and effervesced freely with acid. This is true of specimens from the other localities, so far as examined, and the rock may with propriety be called a calcareous sandstone. Oxide of iron is an important constituent of the rock, and it is probably in the form of protoxide, for the interior portions are greenish-blue, and on exposure become rusty brown or drab, the result of the formation of the sesquioxide. The iron may be present in combination with sulphur; one or two minute grains of pyrites were detected in some of the specimens.

Numerous films of a dark slate-colored substance are distributed in parallel planes through the mass of the rock. They are often coal black, and some are soft, like clay or shale, and are sometimes in small lenticular masses, which can be easily excavated with the point of a knife. Some of the beds contain many more of these masses than others, and they determine the direction of easy fracture of the rock. One of the beds of soft shale was highly charged with black masses, and they were, without doubt, the remains of plants, a coaly substance being distinct in the thickest layers. The films in other parts of the rock were, in most cases, composed chiefly of clay, and may be fragments of shale.

The position of these beds of sandstone is highly favorable to the operation of quarrying, and the stone can be readily loaded at a wharf and ferried over the channel to the city. It will be found to be a highly valuable and elegant building material.

The same formation of sandstone and shales underlies the city, but there is no exposure where the strata can be so conveniently studied as at Yerba Buena, or where they are so free from decomposition and fissures. The strata are apparently much more bent and broken up, and the action of the atmosphere and surface water has extended to a greater depth below the surface. The best section, at the time of my observations, was along Pacific street, where Telegraph Hill had been cut away. At that place the stratification was very distinct, and the alternation of thick beds of argillaceous sandstone, with shales and slate, was visible. Numerous curves and flexures of the beds render the dip variable, but its prevailing direction is eastward. The rocks crop out on the top of the hill, and look like ordinary trap-rock which has been exposed to the weather. These rocks are again exposed along Dupont street and Broadway, and they form the shores of North Point. They also project out into the channel between Telegraph Hill and Fort Point, forming Tonquin Point and Point San Josef. At all these places decomposition of the rock has extended so deeply that the unaltered portions had not been reached by the excavations, and the true color and lithological characters of the rock were not exhibited. At one or two points about the city, however, deep excavations into the rock for wells showed that, in color and composition, the rock was similar to that at Yerba Buena. In fact, the general characters of the strata are the same, and the rusted and decomposed exterior crust of rock has nearly the same appearance at both places. The detailed description of the Yerba Buena stone may, therefore,

be regarded as, in general, applicable to the unchanged portion of the rock at San Francisco, and at other points about to be mentioned. The sandstones at Point San Josef and those of Telegraph Hill are traversed by thin and irregular seams of quartz, running in various directions. These may have had their origin at the time of the intrusion of neighboring igneous rocks, being deposited along the sides of slight cracks and fissures by escaping hot vapors. Veins of carbonate of lime, nearly the same in size and appearance as those of quartz, are also found traversing this sandstone in some places, but the two minerals were not found together. Point Lobos—the outer headland of the Golden Gate on the south side—is likewise of sandstone, similar to that of San Francisco. The continued action of the ocean swell has worn the rocks into rugged cliffs and excavated caverns and arches. Many large masses are detached from the cliff, and lie scattered about in the surf. These isolated island rocks are the places of resort for sea-birds and the huge "sea-lion."

The direction and dip of these strata are not very distinct at this point. The greater part of the formation is hidden from view by an immense deposit of blown sand, and the surf prevents any extended examination under the cliffs. A local trend of a few degrees north of west was, however, observed. On the opposite side, or north shore of the channel, the prevailing dip is westward, and it is more than probable that the rocks of Point Lobos have the same direction. These strata extend eastwardly as far as a little brook that descends from the Mountain lake, and empties into the channel.

Excavations for building-stone have been made on the southeast end of Angel island, which bears northwest from Yerba Buena, and is in the range of the strata. It is composed of sandstone, similar to that on Yerba Buena island, but is not so dark in color or so hard. Specimens which I have examined contain a notable quantity of carbonate of lime. The strata dip westwardly, and the quarry is opened on their upturned edges, and not at the ends of the beds, as at Yerba Buena. The weathered surfaces of the strata present the same rusty color as those at San Francisco and Yerba Buena, and the divisional planes or cleavages are numerous.[1]

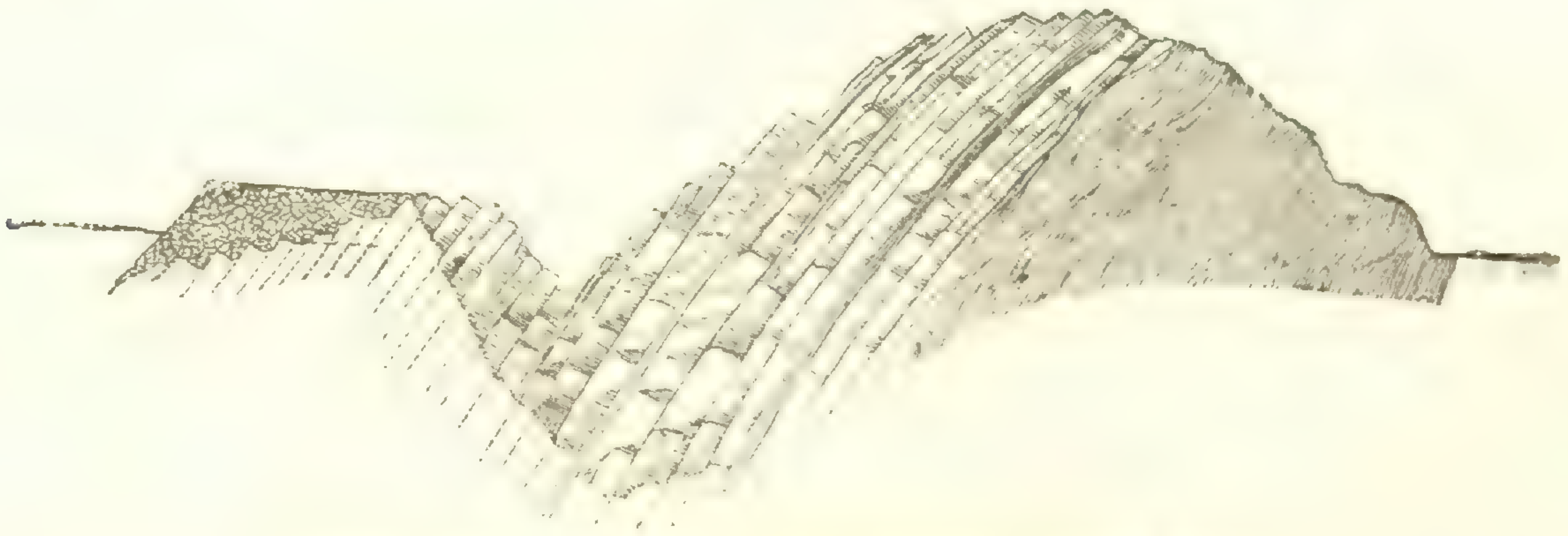
Another extensive outcrop of sandstone, and a quarry, is found at the State's Prison, on Point San Quentin. It is worked, by convicts, to a greater depth than either of the other places that have been described. It is the same sandstone formation, and furnishes a large quantity of good "blue stone." The excavation (in 1854) had extended to a depth of about thirty feet below high-water mark; at that depth the blocks of stone are larger, and without the rusty color attendant on surface decomposition. The trend of the strata is nearly north 50° west; the dip southwest at variable angles, ranging from 45 to 55 degrees. The lay of the strata and the general outline of the quarry is shown in the annexed section; the horizontal line on the left representing, nearly, the height of the waters of the bay.

The strata rise into a slight hill on the east side of the opening, and soon loose the compact, massive character, becoming thinner and more broken, and then pass into a thick body of argillaceous shales.

The operation of quarrying below the surface is, necessarily, more expensive than excavating

[1] I have represented Angel island on the map as wholly formed of sandstone and shales, although I did not visit the western portions. It has, however, the appearance of the sandstone. Lieutenant Belcher, it appears, collected specimens of serpentine on the western side, and the occurrence of jasper rock is noted. It is further stated that the opposite shores of the main land, or promontory on the north, afford specimens of actynolite, mica slate, and talc slate.—*Zoology of Captain Beechey's Voyage: Geology*, p. 175. It is possible that fragments of the slaty serpentine are here mentioned as *talc slate*, and the mica slate may have been a transported mass, for it is not probable that the true micaceous slates occur at that point.

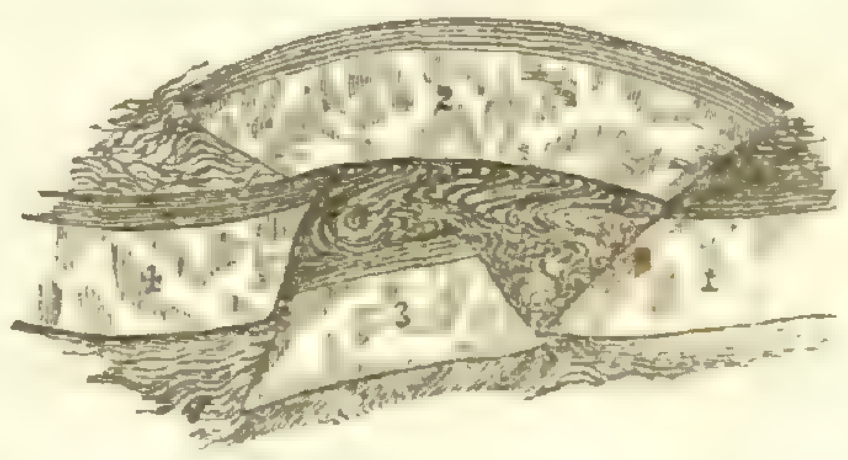
the stone from a bank or elevation; in addition to the inconvenience of working a quarry in this form, the waters of the bay percolate through the bank and accumulate in the lower part of the excavation. The bank of stone does not, however, rise much over 30 or 40 feet above high-water mark, and it is very much decomposed and broken up, so that the excavations are necessarily below tide.



SECTION OF THE STRATA AT THE STATE'S PRISON QUARRY.

Large blocks of stone are taken out of this place. They split readily into various desired sizes, and are easily cut and chipped. When dressed or hammered, the surface has a pleasing shade of color, which is much lighter than the bluish-green stone of Yerba Buena, being more gray. Fragments of the stone effervesce briskly when placed in dilute hydrochloric acid, and many of the blocks are traversed by thin veins and seams of white, crystalline carbonate of lime. Where these veins are exposed on a weathered surface, they stand out above the sandstone, showing their superior resistance to degradation.

The slaty character of some of the beds is well seen in the excavation. Thin layers of only a few inches in thickness occur between the beds of solid stone. These slates or shales are darker than the sandstone, and appear to have been subjected to great pressure. Many bendings and plications of the strata have occurred at this locality, and at one side of the quarry there is an interesting dislocation and fault of one of the beds, which bears interesting testimony to the action of violent compressing forces. This dislocation is represented in the figure.



DISLOCATION OF A BED OF SANDSTONE, STATE'S PRISON QUARRY.

This bed must once have been continuous, the several parts being joined on to each other in the order in which they are numbered. It is now broken in three places, and the two ends of the main portions were pressed together so as to throw out a fragment on each side. The space between the blocks is occupied by highly contorted and crushed shales, enclosing some angular fragments of sandstone.

Stone from this quarry, roughly broken out into blocks, was selling in the city of San Francisco for ten dollars a ton—[1854.] It is readily chipped and dressed, and, when hammered, makes a good surface for the fronts of buildings. It is certainly a valuable building material, and is far superior to the partly decayed and friable stone from the Benicia beds.

Another interesting outcrop of the strata is found at Marin island, a small island about four

miles northeast of the State's Prison quarry, and nearly opposite the Mission of San Rafael. The strata are highly inclined, and dip W. 30° N., at an angle of about 60°, trend N. 30° E.

They are composed of thickly bedded sandstones, alternating with shales, and the stone is more like that from Yerba Buena than that taken from the State's Prison quarry. It has a dark bluish-green color and a fine grain, and the black spots are not so abundant as at the other localities. Abundance of good building-stone can be obtained at this place, and it is accessible for tonnage vessels.

All the points and headlands around Marin island appear to be formed of similar rocks. They outcrop also on the opposite side of the channel, and form low ridges, trending about northwest and southeast. In sailing up the bay towards Benicia, the same strata appear to be continuous, and seem to be the only formation. The strata are exposed at many points along the shores, always with the same rusty drab or brown color.

At Benicia, the hills are soil-covered, and there are few outcrops; but there is an extensive and favorable natural section of the strata at Navy Point, produced by the Straits of Carquinez connecting the Bay of San Pablo with Susuin Bay. The current flows nearly at right angles to the trend of the outcropping beds; and their ends are well exposed along the shore, forming a bluff of slight elevation. The strata are uplifted, being inclined at an angle of from twenty to sixty degrees, and dipping towards the southwest. The trend of the outcrops is 75° west of north, and the strata underlie, or rather form, the hill upon which the government buildings are erected.

These strata, as here exposed, differ somewhat from the outcrops at San Francisco, Yerba Buena, and other places described; but there is much reason to consider them as a portion of the same formation, although they may prove to be much higher in the series. The surface decomposition appears to have been more complete, or perhaps the strata were never so hard and firm as those nearer San Francisco.

The great ridge of conglomerate, already described in the notes, forms the prominent feature of the section exposed at this point. It is the hardest and most unyielding of all the strata, and its resistance to abrasion and atmospheric influences has determined the form of the hill and the shape of Navy Point. It forms a prominent object at several points along the surface of the ground, and is almost the only rock that appears above the soil in that vicinity. The bed is about twenty-five feet thick, and is composed of pebbles and gravel, very round, much water-worn, and chiefly derived from the wear of volcanic or eruptive rocks. Their colors are generally dark; and porphyries, agates, and carnelians are abundant. Their average diameter does not exceed an inch, and many are about the size of beans and peas. They are closely united by a small portion of finer materials. The strata on both sides of the conglomerate consist of alternate beds of soft and friable argillaceous shales, with an occasional layer of gravel and pebbles. Their lithological characters and succession are shown in the following section, enumerating the strata from west to east, or in the order of superposition from above downwards. The measurements which are given are merely approximate, having been determined by the eye, or by pacing in front of the exposed edges in the bluff.

SECTION OF THE STRATA AT NAVY POINT, BENICIA.

SECTION OF THE STRATA AT NAVY POINT, BENICIA.

	Feet.
1. Sandstone, fine-grained and soft, with spherical masses of great hardness inclosed—only about 10 feet exposed	10
2. Sandstone, harder than No. 1, and highly charged with peroxide of iron	15
3. Sandstone, with layers of small pebbles and coarse grains of quartz. Some hard masses also seen. Ferruginous. Fossils and a shark's tooth	20
4. Slaty sandstone in thin layers, hardened by the presence of a considerable portion of oxide of iron. Trend S. 75° E. ; N. 75° W	6
5. Slaty sandstone, similar to No. 4	15
6. Sandstone, fine-grained, soft, regularly bedded	63
7. Sandstone, soft, in beds separated by thin partings of shale, and traversed by thin seams of gypsum, generally in horizontal layers. The shales and the beds of soft sandstone are much stained by oxide of iron	30
8. Sandstones and shales, all soft and decomposing; some of the beds consist of fine-grained white sand. The general characters are the same as the previous beds. Thickness of this series, from No. 7 to the point of conglomerate, estimated to be 600 feet	600
9, *h.* Conglomerate of gravel and pebbles forming the end of the point	25
10, *g.* Decomposed silicious sandstone traversed by nearly horizontal seams of gypsum, and divided in the centre by a thin parting of shale	30
11, *f.* Thin layers of sand or sand and clay, forming a kind of shale	1¼
12, *e.* Decomposed sandstone, containing some hard masses, and traversed by seams of gypsum, partly fibrous	15
13, *d.* Thin layers, finely stratified, like No. 11	1¼
14, *c.* Soft decomposed sandstone	16
15, *b.* Soft decomposed sandstone stained by waving lines of peroxide of iron, looking like the grain of wood	6
16, *a.* A succession of beds of sandstone and thin partings of shale, all more or less discolored by oxide of iron, and traversed by seams of gysum in nearly horizontal lines. Thickness about 150 feet	150

These strata are all conformable, and the combined thickness is a little over one thousand feet. The section commences at the low ground on the western side of the point near a quarry, and extends along the beach, under the face of the bluff, to a little cove, where the rocks are no longer exposed. The dip and general appearance of the strata are shown in the appended section ; an enlarged view of a portion of the series is presented on the sheet of sections, Chapter XIII. This portion is that lying east of the conglomerate, and it is indicated in the descriptive section by letters which refer to the plate. It includes a thickness of about 175 feet.

The quarry was opened in the thickly-bedded sandstone, containing hard, rounded masses, which, when broken open, revealed a bluish nucleus similar in color to that of the rock at Yerba Buena and other localities near San Francisco. These hard masses seemed, at first, like concretions, but they probably originate in the same manner as the spheriods at Yerba Buena—by decomposition of angular blocks. When these nuclei are broken up, they are found to contain small dark-colored plates and fragments of an earthy character, but apparently the remains of lignites. In some of them, the carbonaceous material is quite apparent ; and in the softer and more decayed parts of the rock, I found several specimens in which the organic structure of plants was well exhibited. The small black films in the sandstones of the bay of San Francisco, that have already been described, all lie in planes parallel with the stratification, and are similar to those in the hard masses of this locality ; and I consider them, in part, as of vegetable origin. The thickness of this stratum,

or series of layers, of compact sandstone, containing the hard nuclei, was not ascertained, and at this time I find it difficult to assert with certainty whether it forms a part of the series exposed along the beach. It is recorded as a part of the section in my note-book, but it is possible that the strata were only seen at the quarry, which is several rods distant from the exposed strata along the beach. I have, however, little doubt of the continuity of the strata, and that they are conformable. This is an important point; for the similarity of the lithological characters of the sandstone to that of San Francisco is, under the circumstances, good evidence of the synchronism of the strata at the two places. In other respects, the strata, as exposed in the section, have little resemblance to those around San Francisco. There is no doubt of the presence of the equivalents of the San Francisco sandstone in the vicinity of Benicia, for a similar rock is quarried in quantities and sent down to be used in the construction of buildings. Many of the stones, when dressed and rubbed down, show a central portion of a dark color identical in its characters with the rock from the quarries of the bay.

The thin seams of gypsum, which occur so abundantly in the strata, are not found in layers parallel with the beds; they are nearly horizontal or curved downwards, thus showing that they are the result of infiltration from above. Such is also the origin of the undulating layers of oxide of iron, which in many of the beds are so numerous and parallel, and at the same time so much bent and plicated, that it at first seems as if the bed was formed of compressed and crumpled shales. The uniform width of the stratum, and the parallelism with the adjoining strata, show, however, that the appearances have not been produced by violence. Fine examples of the deposition of oxide of iron in layers and curved lines were afterwards seen in the horizontal strata along Ocoya or Posé creek.

The fossils which were observed were very few and imperfect; with the exception of a shark's tooth, they are mere, broken casts, all the shells being removed, and the forms left in a matrix of sand and peroxide of iron. As near as can be determined, the genera *Trochus* and *Turritella* are represented. The shark's tooth is well preserved, and, according to Professor Agassiz, represents a species of *Lamna* allied to *L. elegans*, Agass., which is found in the *Calcaire grossier* in the environs of Paris, and in the London clay at Sheppy. The description, by Professor Agassiz, of the new species, under the name of *L. ornata*, will be found in Article I of the Appendix. These fossils are regarded as sufficient to establish the Tertiary age of the strata from which they were taken.

It will be seen from the observations recorded in the Itinerary that the strata of Benicia are prolonged towards the south and southeast, on the opposite side of the straits. A conglomerate and similar sandstone to that of Benicia was found south of Mount Diablo, at Livermore's Pass. The strata are believed to have a wide extent in that direction, and to form the greater part of the Contra Costa or Central range. The sandstone and shales of San Francisco have a similar extension towards the south, and it is probable that the stratified rocks at the New Almaden cinnabar mine are of the same age. These strata much resemble those of San Francisco, and are similarly associated with serpentine. A great body of sandstone is found still further south, flanking the San Juan mountains, on the side towards the valley of the Salinas, and I am inclined to include this in the same group. At the last-mentioned point it shows a great thickness, and crops out in great, massive beds, many feet in thickness. The strata dip away from the axis of the range at an angle of about forty degrees.

The prolongation of this group of strata is not, however, confined to the southern ranges of the Coast Mountains. The rocks are found developed in the mountains north of the Golden

Gate. The outcrops of Angel island, State's prison, and Marin island are on the north, and have already been noticed; but it is probable that the exposures of the beds are greater in the interior. The shore of Saucelito bay, on the west of these localities, is formed of sandstone, similar to that of the other localities in the vicinity, except in color. It is lighter, and more like specimens which have been obtained from Fort Ross, many miles north, on the shore of the Pacific. A block of sandstone, brought down from the vicinity of the coal-beds of Bellingham bay, closely resembles specimens from the quarries about San Francisco, not only in color, but in mineral characters; it is thus rendered probable that the formation is the same, although the evidence presented by mineralogical resemblances can never be regarded as satisfactory.

The wide development of the formation is, however, rendered certain from the evidences presented in the immediate vicinity of San Francisco. The great thickness which the series attains—probably over 2,000 or 3,000 feet—and the even grain of the thick beds of sandstone over large areas, together with the remarkable uniformity of the strata, indicate that they were formed in a wide-spread ocean or sea. The thick beds of shale attest the depth and comparative quiescence of the water. Independently of these considerations, the wide extent of the formation has been made known by observation; it forms a greater part of the hills and mountains around the bay, and, so far as explored, a considerable part of the mass of the Coast Mountains. It is believed to be the most extensive and highly developed sedimentary formation of the California coast, and may appropriately be known as the *San Francisco* or *California sandstone.*

It is greatly to be regretted that, as yet, the evidences of the age of this formation are very few and unsatisfactory. The rocks near San Francisco, so far as I examined them, are singularly devoid of fossils, not a single shell having been observed in them. Masses of similar sandstone containing fossils are, however, thrown up by the surf upon the beach south of Point Lobos, and there is little reason to doubt that they are broken from a submerged outcrop of the formation. The rock, in color and grain, is very similar to the adjoining sandstone of the Point, but it is not quite so hard. It at first appeared possible that these masses were from strata formed out of the comminuted debris of the sandstone, and thus more modern or of recent origin. I am now, however, of the opinion that they are broken from the solid ledges of the San Francisco sandstone, under water, and that the fossils may safely be received in evidence of the age of the formation. The fossils are chiefly *Scutellæ,* and represent the period of the Tertiary. They are firmly imbedded in the rock, and lie thickly together, three or more being often found within the thickness of an inch. It was found to be impossible to cleave these masses of sandstone so as to expose fresh surfaces of the fossils. The rock is calcareous and tough, and the lime of the Scutellæ has so completely crystallized that the fragments cleave into rhombohedrons, like calc spar. The fossils appear to have determined the form of the fragments of rock, for the latter are generally discoid, and faced on each side by the worn surfaces of the Scutellæ. The edges of the fossils also appear on the sides of the specimens, and it is evident that the lime has been less easily abraded by the surf than the granular sandstone. The structure of the fossil is very beautifully shown in several of the specimens, and a figure of one of them is given on Plate IV, fig. 30. I propose for this species the name *Scutella interlineata,* and append a description,[1] prepared for me by Mr. William Stimpson.

[1] SCUTELLA INTERLINEATA.

The specimens are imperfect, but the ambulacral star is apparently central, the petals equal, and closed, or nearly so, at their extremities. The tubercles being mostly worn off in the specimens before me, there are two rows of irregularly pentagonal plates in each inter-ambulacral space, which gradually increase in size toward the margin. A small portion of the surface upon which tubercles still remain shows these to have been sporadic, very numerous and crowded. The ambulacral petals are transversely lineated with impressed lines across their entire width, the thread-like lines connecting the

These fossils occur in considerable numbers along the beach, and it is probable that a stratum of these interesting relics may be found, in place, along the shore further south.

The block of sandstone from Bellingham bay contains two large Pectens of the age of the Tertiary, and this furnishes additional evidence of the Tertiary age of the San Francisco sandstone. The fossils of Benicia—the *Trochus*, *Turritella*, and shark's tooth, *Lamna ornata*—point to the same conclusion, the only doubt being as to the connexion of the strata. The fossiliferous stratum may be much higher in the series than the rocks about San Francisco. It is not impossible that a portion of the Upper Cretaceous is represented, although there is nothing to indicate it in the lithological characters of the strata. The occurrence of Cretaceous strata in the northern part of the State[1] renders this more probable.[2]

The formation throughout its extent, so far as explored, has been uplifted and thrown into wave-like flexures. A body of the strata in a horizontal position is not known. The dips are generally at angles of from twenty to sixty degrees, and in such directions as to indicate the existence of a series of anticlinals and synclinals. The trends of the strata conform so nearly with the direction of all the principal ridges and headlands as to show that the flexures of the rocks have determined the relief of the region. This direction is nearly northwest and southeast, and is clearly shown on the maps of the Bay by the parallel lines of coast. The promontory extending northwest from Angel Island finds its continuation in this island, and beyond it, in the island of Yerba Buena, indicating the presence of a long anticlinal axis. This is rendered more probable by the dip of the strata at the island, and the apparently reverse dip of the beds on the opposite shore at San Francisco. It is probable that the channel between the city and Yerba Buena occupies a synclinal depression. It was not possible to follow out the flexures of the strata from North Point westward to the serpentine ridge of Fort Point, but the dips that were exposed were sufficient to warrant the conclusion that the strata were much flexed and folded between the two places, and indicated that the two principal hills of the city were formed by the summits of flexures. The folded condition of the strata is represented in the little section on page 155, drawn to show the relations of the rocks between the city and the shore of the Pacific. The curved lines show the *probable* bending of the great mass of the strata.

Indications of an anticlinal fold of the strata were apparent at Benicia. The strata exposed on the opposite shore of the little bay, or cove, which terminated the section on the east, appeared to dip in a direction opposite to the others. Such foldings were, however, more distinct further south, in the hills west of Mount Diablo.

pores of the two inner rows, as well as those of the inner and outer ones. The position of the anus could not be made out; it is probably infra-marginal. The ambulacral furrows of the inferior surface are apparently but little ramified.

Diameter of the largest specimen $4\frac{1}{10}$ inches; height at the middle 0.48 inch. This specimen was presented to me by Dr. C. F. Winslow, formerly of San Francisco.

[1] Discovered and announced by Dr. J. B. Trask.

[2] A short paper on the lithological characters and probable age of the San Francisco sandstone was read by the author, with the permission of the War Department, at the meeting of the American Association for the Advancement of Science Providence, 1855. See Proceedings, 9th meeting.

The most distinct contortions and highly-inclined positions are, however, shown by a class of rocks which have not yet been mentioned. They are, to all appearance, a metamorphosed or changed portion of the sandstone formation. They are found outcropping near the Presidio, south of the Mission, and form the highest elevations of the north shore of the Golden Gate. Lime Point is entirely formed of these rocks, and it is probable that they compose nearly the whole peninsula from Point Cavallos to Point Bonita. At Lime Point they exhibit regular stratification, with the planes nearly vertical, or inclining westward. Portions of the strata are very finely stratified, the layers being not over half an inch thick, and yet they are well defined and apparently very hard. The whole series is enormously thick, and the principal beds are seen to form the crests or culminating points of the principal ridges, and to outcrop in long lines on the surface. Several of the small islands, or large rocks under Lime Point, consist entirely of these metamorphic sediments, and rise above the waves with nearly vertical sides, like steeples. In these islets, and on Lime Point, there are beautiful flexures and folds of the strata, some of them of considerable extent, and others are local, showing many bends and short angles within the space of a square yard, resembling the compressed and crumpled leaves of a book in the number of the thin layers, and their conformity through all the bends. One of the most interesting displays of these plications is found in the sides of Needle rock, a high column rising from the waves near the base of the Point.

a, a, a, San Francisco sandstone; *b,* Metamorphosed sandstone; *s,* Serpentine of Fort Point.

The lithological characters of these strata are very interesting. They are hard, flint-like, and jaspery, and occur of various colors. The most common color is a dark reddish-brown, or a chocolate color, but this is often intermixed with yellow and green. Indeed, some of the fragments are beautifully spotted and banded with different colors, and form good specimens of ribbon-jasper, or prase. Quartz, in thin irregular veins, is a common accompaniment of the rock, and traverses it in all directions without any regularity in the trends of the fissures. It appears, in many cases, to form a complete coating around fragments of the rock, so as to isolate them from the adjoining portions. The flat surface of one of the specimens, when viewed at a short distance, appears as if covered by a tangled mass of white cord. It is probable that these flinty strata are similar to those seen by Professor Dana, and described in his report as *prasoid* rocks.[1]

Similar rocks are found along the road south of San Francisco towards San José, and at New Almaden. At the latter place the color is much lighter, and the crooked quartz veins are absent. They are, however, very hard, and show the original alternation of shales and sandstone.

[1] Report on the Geology of the United States Exploring Expedition under the command of Lieutenant Charles Wilkes, U. S. N.

In the bank, just behind the smelting works of the quicksilver mine, a slight exposure of the strata shows a very interesting flexure of the beds:

FLEXURE OF THE METAMORPHIC STRATA—NEW ALMADEN.

Although the direct transition from the unaltered sandstone and shale to these metamorphic strata has not been observed, there is little doubt they are of the same formation, and that the jaspery condition is due to igneous agencies. The chemical composition of the sandstone and the shales is favorable to such a result. It is regretted that analyses of each, and of the metamorphosed portions cannot be presented.

ERUPTED ROCKS—SERPENTINE.

The extensive metamorphism, and the uplifted condition of all the strata, indicate the proximity of igneous rocks. They are not exposed, however, in the vicinity of San Francisco to an extent that the effects which have been produced would lead us to expect. The nearest exposure of the granitic rocks, which is known, is at the Farallones islands, twenty miles out at sea, off the entrance to the Golden Gate, and at Punta de los Reyes, about the same distance up the coast. Granite may, however, occur in the mountains, south of the city, at a nearer point, but this is very doubtful. It may also be found at Point Bonita. It probably forms the principal ridge west of New Almaden, and there is reason to believe that the sandstones and shales and the metamorphosed rocks rest against it. Granite is found in close proximity with the thick strata at San Juan, but the relations of the rocks could not be readily determined. Trappean intrusions and serpentine occur at New Almaden.

The metamorphosed strata of Lime Point appear to be underlaid on their eastern margin by a dyke, or intrusion of a hard, compact trappean rock, which does not rise far above the tide-level; its presence might, therefore, be easily overlooked. The line of junction between the two formations is also indistinct, but may be traced around the base of the cliff, at a uniform elevation above the water, for a long distance. The position of this rock is indicated upon the map. It appears to have resisted the action of the surf and currents of the channel so well, that the degradation and undermining of the cliff has nearly ceased, it having continued until the softer metamorphic strata were left secure beyond the reach of the waves. The proximity

and direct contact of this rock of igneous origin, with a portion of the jaspery strata, indicate that it has caused their metamorphosis. It is, however, difficult to conceive that such extended effects were produced by this rock, which has such a limited exposure at the surface, unless we conclude that it has a broad subterranean extension.

The formation next in importance to the sandstone, in point of extent and development in the vicinity of San Francisco, is the serpentine, or serpentinoid rock, of Fort Point. It forms a high and prominent ridge about midway between the shore of the Pacific and the Bay of San Francisco, and extends in a northwest and southeast direction, abutting upon the Golden Gate and forming Fort Point. The width of the ridge is between one and two miles, but its extension southward is not accurately known. It is partly obscured in that direction by sand, but forms a knob at the Orphan Asylum, near the Mission. It is bounded on both sides by the San Francisco sandstone, and its end, at the Golden Gate, forms a bold bluff facing the Pacific. Fort Point is its extreme northern point, and formerly presented a high bluff with a flat table-like summit, upon which the Mexican fort was built.[1] This has recently been cut away to prepare for the erection of new fortifications. This cutting down of such a large mass of the rock exposed a broad surface of the interior, and permits its structure to be conveniently studied. The rock, in its appearance, is unlike the serpentine of Hoboken, New Jersey, and Staten Island, New York; nor is it like the serpentine of Milford and New Haven, Connecticut; being of a darker color, harder, and filled with distinct crystals of diallage, from one-eighth to one-quarter and half an inch in length. These present brilliant cleavage surfaces when a mass of the rock is broken up. The fracture of some of the dark portions of the rock is sub-conchoidal, the resulting surfaces being smooth, and, in this respect, differing from the serpentines mentioned. Another, and a prominent peculiarity of the rock is its globular character, it being made up of nearly spherical, boulder-like masses, included in a shaly or slaty portion that readily splits up and falls into fragments on exposure to the air. These slaty portions present the common smoothed or furrowed appearance sometimes seen on the surfaces of both igneous and sedimentary rocks where they have been rubbed together, under great pressure, as in the walls of mineral veins. It fills all the space between the masses, and gives them the appearance of having been coated with a soft plastic cement. The color of these globular masses is dark olive-green; they are very hard and compact, and not only contain the crystals of diallage, but in some instances are traversed in every direction by thin veins of amianthus or chrysotile, with the fibres transverse to the walls. These seams are generally very thin, and, by intersecting, divide the rock into masses not larger than a nut, causing it to exhibit a curious reticulated appearance where the surface is weathered. A similar character was observed in the serpentine at New Almaden.

At the Orphan Asylum, the compact portions of the rock, which break with a conchoidal fracture, are also traversed by thin seams or bands of a green mineral, non-crystalline, and about as hard as serpentine. It is delicately shaded in lines parallel with the walls, looking somewhat like a narrow green ribbon, of light color. With the exception of some small nodules, of a white powder, probably arragonite, these were the only minerals observed in connexion with this rock. The slaty portions were light-green in color, and had a greasy feel, like talc, rendering the surface of the rocks at Fort Point very slippery and difficult to climb.

The hard and dark-colored portions of the rock were used in the construction of the Orphan

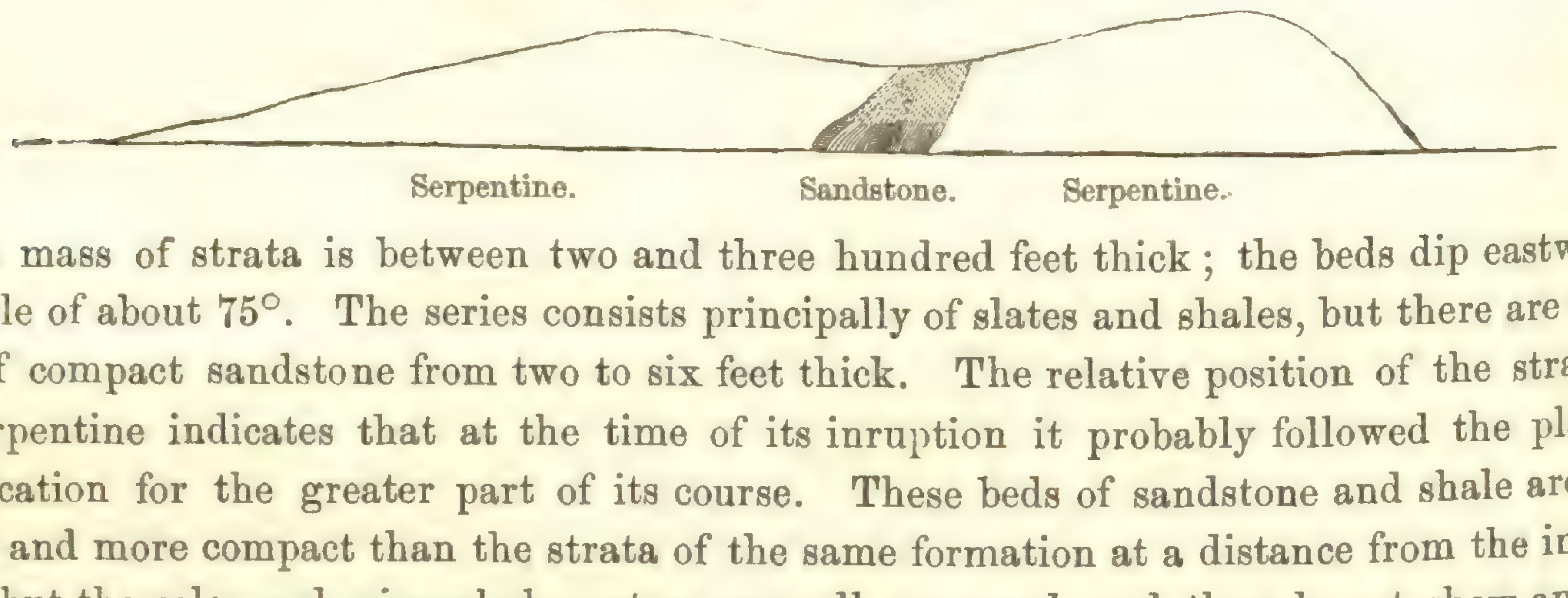
[1] According to the notes of Lieutenant Belcher, serpentine is found on the north shore of the Golden Gate, between Point Bonita and Point Diavolo.—*Zoology, &c., of Captain Beechey's Voyage.*

Asylum; but there is nothing to recommend it as a building stone, except, in this instance, its presence upon the spot. It is not well calculated to resist the action of the weather.

It is very probable that the higher portions of Mount Diablo are formed of a similar serpentine. A large quantity of rock was once quarried there and taken away, under the supposition that it contained gold. A fragment of this was obtained; it proves to be a mass of diallage or bronzite in rough crystals, with the usual metalloidal lustre. It closely resembles the bronzite of Bacher Mount, Styria, which occurs with serpentine.

The ridge of compact serpentinoid rock at Fort Point appears to be eruptive, and to be more recent than the sandstone of the bay of San Francisco. It appears probable, also, that the strata of sandstone and shale were much uplifted or disturbed by its intrusion, although the great flexures of the strata, and perhaps the principal metamorphoses, were, in all probability, attendant upon the formation of a granitic axis of considerable extent, but which, in the vicinity of San Francisco and the Golden Gate, is submerged in the waters of the Pacific. That the strata were disturbed by the serpentine, is indicated by the relative positions of the rocks, as seen in the exposures along the shore of the Golden Gate from San Francisco to Point Lobos. These positions are shown on the little section, page 155, which is intended to represent the succession of the formations along the line A, B, upon the map, and the *probable* flexures of the strata. The sandstone is found upon both sides of the serpentine, and appears to rest upon it on the east, and to underlie it on the west. An outcrop of metamorphosed rock is found near the line of junction on the east side, but on the shore near the beach it is not visible. At this point, however, we find a body of sandstone strata, intercalated or imbedded in the serpentine, as represented in the annexed figure.

SANDSTONE AND SHALES IMBEDDED IN SERPENTINE.



This mass of strata is between two and three hundred feet thick; the beds dip eastward at an angle of about 75°. The series consists principally of slates and shales, but there are several beds of compact sandstone from two to six feet thick. The relative position of the strata and the serpentine indicates that at the time of its inruption it probably followed the planes of stratification for the greater part of its course. These beds of sandstone and shale are much harder and more compact than the strata of the same formation at a distance from the intrusive rock; but the color and mineral characters are well preserved, and they do not show any signs of change from igneous action.

The line of contact of the serpentine with the outlying beds of sandstone on the west side of the point was not seen, but the character of the surface on that side indicates that the strata dip under the serpentine. The valley through which the little brook, leading from the lake, flows is coincident with the line of junction between the two formations.

Serpentine is found to outcrop, in connexion with sandstone strata, similar to those of San Francisco, in the hills between the southern end of Tomales Bay and the Mission of San Rafael. It is also reported to be an abundant rock throughout the Coast Mountains. Wherever it came under my observation it presented the aspect of an intrusive rock, and I have so regarded it. There is little doubt that the outcrops have undergone great changes, even to a great depth, by the action of percolating water and the atmosphere.

ALLUVIAL AND DRIFT DEPOSITS.

Around the shores of the Mission Bay, and near the road leading from the city to the Mission, there are extensive flats of swampy land of alluvial origin. The surface consists of a very thick turf, which, when cut out and dried in the sun, is suitable for fuel. This is underlaid by thick strata of clay, which have been penetrated to the depth of 50 feet or more in several places by boring for Artesian wells. This clay has a dark bluish black color, is very fine, and when first removed exhales a putrescent odor, probably due to the decomposition of leaves and vegetation, which are sometimes found in the borings. Between Fort Point and Point San José there is a narrow, swampy tract, but little elevated above tidewater, which appears to be like that near the Mission, having also a thick layer of turf. This tract is separated from the water of the channel by a narrow dyke, or beach, formed of sand and rounded stones. This has evidently been thrown up by the waves, and piled upon the alluvium. This can be easily seen at low tide, for on the outer side of the sand-beach, and just below the surface of the water at low tide, there is a shore of turf, and an abrupt descent from its margin to deep water. Large masses of the turf are dislodged and thrown up by the waves upon the overlying sand. It is not easy to account for the formation of this peat swamp, which certainly appears to have been much more extensive, and to have required a permanent barrier on its seaward side, as one of the conditions of its formation. A great change in the position of the sea relatively to the land has undoubtedly taken place, for the present action of the sea is directly adverse to the deposition of alluvium, or the formation of a marsh. It is encroaching rapidly upon the margin of this deposit of fine alluvial clay, and it is evident that a formerly existing barrier to the action of the sea has been broken away. What the nature of this barrier was it is difficult to decide. It may not have been a wall-like barrier, like a bar or reef, but the water may have been shoal, and free from swift currents, so that a gently sloping beach of mud, or mud-flats, were formed.

The point of serpentine rock (Fort Point) projects out into the channel, and acts as a natural breakwater to the shore immediately east of it, thus preventing the entire destruction of the alluvial tract. This point is fully exposed to the heavy surf of the Pacific and the violent currents of the channel. It has been much broken down and abraded under these continued influences, consequently the channel has become widened, and the currents have acted with more and more force upon the adjoining shores. The powerful action of the currents and surf are well exhibited to the leeward of the point, where wrecks of vessels lie partly buried in accumulations of sand, pebbles, and even large rocks. The long government wharf, which has been constructed in the cove east of the point, consists of large cribs, filled with rock, placed at intervals, so that the currents could flow between them. These cribs have so modified the action of the currents flowing inland that an immense deposit of sand and boulders is in process of formation on the lee side. The cribs that were constructed beyond the beach, and that were formerly surrounded with water, are now half imbedded in sand. It is probable, therefore, that when the channel was much narrower than now, a sea-wall or beach was formed, leaving a lagoon on the inner side, which became gradually filled up by the wash from the hills. The gradual widening of the channel permitted the sea to encroach and wear down the wall of sand and shingle, throwing a portion of it further inland, until at length it was completely underlaid by the alluvium.

A wide margin of recent or alluvial deposits is found on the shores of the bay opposite to San Francisco. It is most extensive at the mouth of San Antonio Creek. Further south, at the

lower end of the bay, there are broad, alluvial meadows, or marshes, and an extensive tract is left bare by the tides. The extension of this alluvian inland, at a higher level, forms the broad and fertile plains of San José. These deposits are bordered by the more dry and sloping plains of coarser soil, formed by the debris and wash from the hills.

On the hills about San Francisco there is a slight formation of drift, either alluvial or composed only of the wash from the hills. It does not show upon the surface in the form of either transported boulders or gravel, but is limited in extent, and occupies the lower parts of the principal depressions. In excavating a tunnel from the small lake on the west slope of the serpentine ridge, a portion of this formation was cut through, and at its junction with the serpentine rock, about 80 feet below the surface, fragments of wood were taken out. They were imbedded in black clay, like sea mud, and were much compressed and flattened out, and partially converted to lignite. Bones were also found in this clay, 18 feet below the surface. One of them appeared to be the rib of an animal not larger than a deer. A fragment of a large bone was also taken from an excavation at the foot of Telegraph Hill. It is about eight inches long and four in diameter, and is nearly triangular in its cross-section.[1]

In boring through the earth outside of the old water-line of the city, at the site of the new custom-house, in order to ascertain the nature of the foundation, several beds of sand, clay, and gravel were found to succeed in regular order for a depth of 60 or 80 feet. This locality is at, or below, tide level, and we thus find that the sandstone strata in the channel are overlaid by drift or detrital deposits of considerable depth. It is between these accumulations of drift, or alluvium, and the rocks, that sheets of water or water-bearing strata are found, and are reached by Artesian borings in various parts of the city.

The sandstone and shales of the hills upon which the city is built are overlaid in many places by a covering of soil, which appears to have been derived from the decomposition of the strata. This soil is found to be a good material for making bricks, and it is extensively used in that manufacture. This fact shows that the rock contains a large per centage of alumina, and the presence of oxide of iron is not only shown by the rusted color of the weathered rock, but by the deep red color of the burned bricks. Wherever this soil has been cultivated it has been found to yield good returns.

SAND-DUNES.

On the Pacific side of the San Francisco peninsula there is an extensive sand-beach, reaching for several miles north and south, and a long distance inland. A wide area is thus covered by loose, dry, sea sand, and it has the aspect and character of a desert. This sand is moved about by the wind and is constantly progressing inland, being thrown into wave-like hills, which move forward and bury shrubs and trees that lie in their path. The extensive formation of blown sand within the city limits has undoubtedly been accumulated by the action of the sea winds upon the sand of the beach, it having been transported from one side of the peninsula to the other.

The sand-hills formerly occupied a wide area in Happy Valley, rising in constant succession, one beyond the other, to various heights, from 20 to 60 feet or more, rendering the region almost impassable for vehicles. Most of these hills are now levelled, and houses have taken their place. Remnants of them may, however, be found along the newly opened streets, where favorable opportunities are presented for the examination of their internal structure. Many

[1] These bones are in the possesion of Dr. C. F. Winslow, formerly of San Francisco.

interesting exposures of the same character are visible in other parts of the city; and in all the localities, the sections present well-defined lines of stratification, not horizontal, but inclined in various directions, corresponding with the direction of the wind at the time of the deposition of the sand. These lines are very numerous and fine, and appear to be formed partly by thin layers of black iron-sand, which, being heavier than the rest, is not so readily moved; it is frequently seen forming the outer layer of a bank that has been swept by the wind. Blown sand is also found in long drifts and dunes on Point San José. It is in a state of constant progression, passing over the point, under the influence of the wind, and falling into the water on the opposite side. Some large drifts are found at that place, and the grains of sand are unusually coarse. The surface of one of these drifts, when the wind is blowing hard, presents a curious appearance; the sand sweeps along in a constant stream, which does not rise more than one or two feet from the surface, and when the light strikes upon it, it produces a peculiar halo, enveloping the drift. The same peculiar ripple-marks that are so well shown in the beds of streams and on the sand-hills of the Desert, are developed here in the most beautiful manner; they are seen on the broad, rounded surfaces of the hills in all directions.

Most of the hills in the city and its vicinity, where they were partly sheltered from the wind, are, or were, covered with a thick growth of dwarf trees and shrubs, (*chamisal*,) which prevented the wind from acting upon their surfaces and removing the sand.

It is impossible to determine, with any accuracy, the ages that must have elapsed since this sand began to accumulate in Happy Valley. The progress of such hills is not uniform and constant, for, under certain circumstances, they remain stationary for long periods. Whenever the vegetation is removed, or a cutting is made, and the wind is allowed to act upon the surface, or to strike a hill in a new direction, the motion of the sand is rapid, and a large hill is soon carried away and piled up in a protected place, where the sand remains, secure from further violent action.

The Pacific coast presents many favorable opportunities for studying the phenomena of drifting sand and the formation of dunes. Perhaps no point is more favorable than that partly described—the sand-beach and dunes of the San Francisco peninsula. The sand of the beach is constantly acted on by the wind, and is thrown into hillocks of various forms and magnitude. The observer may, in an hour's time from the city of San Francisco, place himself in the midst of this desert-like expanse, and, having viewed the production of sand-hills and drifts, he may, as he returns, study their internal structure and curvilinear stratification in the numerous sections of the hills along the streets.

ARTESIAN WELLS.

Artesian borings for water in the city of San Francisco have become so numerous within three years, that it is almost impossible to ascertain their number and localities. Water appears to be found in all parts of the city around the hills, and generally at a depth of not more than one hundred and fifty feet; but the depth to which the borings extend varies with the locality. In Happy Valley, and towards the Mission, the borings are generally successful at a depth of fifty to seventy-five feet, the water rising to the surface. In that part of the city north of California street, the depth of the wells increases; one at the corner of California and Montgomery streets being eighty-five feet deep, and at Montgomery block one hundred and sixty feet. Another, between Clay and Merchant streets, is one hundred and forty-two feet. The depth to which

the borings are carried, increases from the base of the hills towards the bay, and many of the wells are bored down through the salt water of the bay.

None of these Artesian borings have been carried downwards into the sandstone strata; they only pierce the superficial drift or alluvium. Several veins or strata of water are generally found; and when the borings first commenced, an overflow was generally obtained.

The formations that are successively passed in boring, are sands and clays, and the water is found to rise from the sandy strata alone. Towards the Mission, a very heavy and thick formation of blue clay is met with, containing roots and leaves partly decomposed, and giving off a disagreeable odor. This clay is over fifty feet thick, and water is found below it. The configuration of the underlying strata of sandstone and shale is highly favorable to the success of Artesian borings in the overlying drift or detrital accumulations. It is possible that water could also be obtained from the slaty layers between the compact sandstone strata; but the drilling of the rock would be attended with great expense, and it is questionable whether the formation is not so compact and dense as to prevent rapid infiltration, or a subterranean flow of water.

Some of the wells in the city are eighteen inches in diameter, and cased with cast-iron pipes; others have a simple and temporary lining of sheet-iron like a stove-pipe. The cost of the wells, complete, with the ordinary lining, is about four dollars per foot.[1]

At the villages of Santa Clara and San José, Artesian borings have been entirely successful. At San José, during the past winter, (1853,) the earth was bored to a depth of seventy-eight feet, through the fine alluvial clay of that valley. At that depth, the auger suddenly dropped into a stratum of water and sand, and, on being withdrawn, the water followed it to the surface and overflowed freely. The column has since been raised several feet by the addition of pipes, and an elevation sufficient to irrigate the surrounding lands is attained. No diminution in the volume of water discharged has yet been observed; but several other wells are about being sunk, which will perhaps reduce the quantity.

Several other wells have been constructed with satisfactory results. One of the borings was remarkably successful; at the depth of about seventy-five feet, a rush of water to the surface took place, and has continued to overflow without diminution. Such is the pressure and force with which this water rises, that it has been found difficult to control it and prevent it from overflowing the adjoining grounds. Another is reported to have been sunk to the depth of two hundred and twenty-five feet, and to yield seventy-five gallons a minute. The drainage from the different wells forms a brook large enough to drive a saw-mill. The success attending the Artesian borings in that alluvial valley is so general, and the advantages obtained are so great, that they are becoming very numerous. The Artesian wells can also be constructed at an expense that of ordinary wells.

[1] I am indebted for many of these facts to Mr. Hopkins, who has been engaged in boring wells in San Francisco for two years past. (February, 1854.)

CHAPTER XIII.

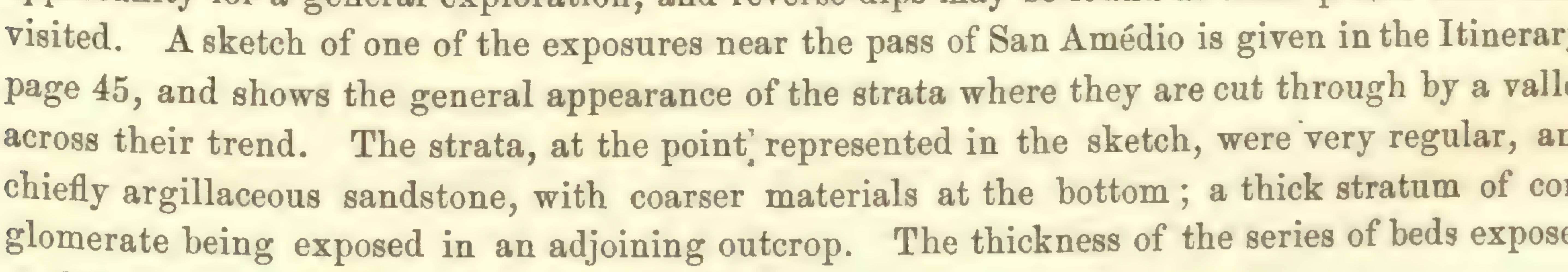
TERTIARY FORMATIONS OF OCOYA CREEK, MONTEREY, AND OTHER LOCALITIES.

Eocene formations at the head of the Tulare valley.—Eocene fossils.—Ocoya creek tertiary.—Extent of the formation.—Soft clay-hills.—Absence of vegetation.—Steep slopes.—Lithological characters.—Pumice-stone and volcanic ashes.—Section of the strata.—Charcoal.—Deposition of oxide of iron by infiltration.—Formation of gypsum.—Resemblance of the lines of oxide of iron to those produced in strata by pressure.—Fossils.—Shells.—Shark's teeth—Mastodon.—Silicified wood.—Evidences of shallow water and currents at the time of the deposition of the fossils.—Resemblance to a beach accumulation.—Probable miocene age of the deposits.—Former existence of volcanoes in the Sierra Nevada.—Tertiary of Carrizo creek and the Colorado desert.—Lithological characters.—Concretions.—Pebbly drift along the Colorado and Gila.—Miocene fossils.—Tertiary of San Diego.—Trap-dyke.—Fossils.—Tertiary of the Bernardino sierra and San Fernando.—Strata of Los Angeles and San Pedro.—Fossils.—Tertiary at Monterey.—Lithological characters.—Infusorial beds.—Fossil shells.—Foraminifera.—Tertiary of the southern end of the Great Basin.—Silicified stems.—Post pliocene deposits of Monterey, San Pedro, and San Diego.—Recent elevation of the coast.—General observations on the tertiary formations.—Miocene at the base of the Sierra Nevada.—Comparisons.

EOCENE OF THE SOUTHERN END OF THE TULARE VALLEY.

The mountains at the southern end of the Tulare valley have a central axis of granitic and metamorphic rocks, which form the high ridges and peaks; but the lower ridges on the north side consist of thick strata of sandstone and conglomerate, upraised at various angles, but generally dipping away from the granite or towards the valley. The strata appear to form a succession of escarpments facing the granite, as shown in the annexed section.

IDEAL SECTION AT THE HEAD OF THE TULARE VALLEY.



All the dips which were observed were towards the north; there was, however, but little opportunity for a general exploration, and reverse dips may be found at other points than those visited. A sketch of one of the exposures near the pass of San Amédio is given in the Itinerary, page 45, and shows the general appearance of the strata where they are cut through by a valley across their trend. The strata, at the point represented in the sketch, were very regular, and chiefly argillaceous sandstone, with coarser materials at the bottom; a thick stratum of conglomerate being exposed in an adjoining outcrop. The thickness of the series of beds exposed at this point is probably not less than 2,000 feet.

No fossils were visible at that place; but several miles east, at the entrance to the Cañada de las Uvas, a boulder of sandstone full of fossils was dicovered among the drift, which had apparently been brought out of the Cañada by floods along the bed of the brook. This boulder was of a compact sandstone, of a brownish-gray color, and so filled with shells that it could

scarcely be broken without fracturing one or more of them. The shells were perfectly preserved, and when broken out, looked almost as fresh as if recently taken from the water. They were neither stained nor softened.

According to Mr. T. A. Conrad, the period of the Eocene is unequivocally represented by these fossils. He describes fifteen species: *Cardium linteum, Dosinia alta, Meretrix Uvasana, M. Californiana, Crassatella Uvasana, C. alta, Mytilus humerus, Cardita planicosta,* Deshayes, *Natica œtites, N. gibbosa,* Lea, *N. alveata, Turritella Uvasana, Volutatithes Californiana, Busycon? Blakei,* and *Clavatula Californica.* Eleven of these are regarded as new, and they are all described in Mr. Conrad's report, Appendix, Article II. Figures are also given on Plate II. It is an interesting fact that three of the species are indentical with well-known forms of the Atlantic slope. Mr. Conrad's observations on these fossils are exceedingly interesting, and for convenience are repeated here. "The Eocene period is unequivocally represented by the beautifully perfect shells from the Cañada de las Uvas, which, though not found in situ, are evidently derived from strata occurring on the Pacific slope of the Sierra Nevada. This is very remarkable, inasmuch as three species correspond with forms of Claiborne, Alabama, and seem to indicate a connexion of the Atlantic and Pacific oceans during the Eocene period. The vast distance between the two localities will account for the general distinction of species, and it was indeed an unexpected result to find any identical. If I had imagined any eastern species to occur in California, it would have been the very one which does occur, and apparently in abundance—that 'finger-post' of the Eocene, *Cardita planicosta*—a fossil of the Paris basin, and also abundant in Maryland, Virginia, and Alabama. This species originated and perished in the Eocene period, and is so widely distributed that it may be regarded as the most characteristic fossil of its era." We thus find an identity of fossil species in nearly the same latitude, but separated by a distance of over 2,000 miles, and on the opposite sides of lofty mountain chains.

Although these fossils were not taken from the sandstone strata which have been described, there is little doubt that they were broken from a prolongation of the same series. Their source could not be found in the Cañada de las Uvas near the line of exploration, and it was probably further west, along some of the side ravines.

It is very desirable that further explorations should be conducted in that region, and the locality of these beautiful fossils ascertained if possible. It will doubtless prove exceedingly rich in interesting species, and, judging from the per-centage of new species among those procured from one block hardly a cubic foot in size, we may expect valuable additions to fossil conchology to result from its examination.

Several specimens of a compact sandstone were brought to me by one of the party from the vicinity of the pass of San Amédio. They contain fossils of the genera *Cytherea* and *Tellina.*

OCOYA CREEK—MIOCENE.

The most extensive Miocene deposits examined during the course of the survey were at the base of the Sierra Nevada, around the Depot Camp, at Ocoya or Posé creek. In travelling southward towards the Tejon, smooth, rounded hills were encountered soon after leaving Moore's creek, and became more elevated and numerous beyond White creek. The formation, however, which appears to be well represented by the fossils of Ocoya creek, extends in a continuous belt along the base of the Sierra Nevada, from White creek to Ocoya creek, and beyond it for many miles to the southward, forming high banks on both sides of Posuncula or Kern river, and even extending in a narrow strip to the Tejon. This belt of horizontal strata is lenticular in form,

Scale
10 20 30 40 50 feet
1. Section at Navy Point Benicia
2. Section at Bear Creek
3. Section at Ocoya or Posé Creek
Bear Creek

its longer axis being parallel with the mountains, and its greatest width being about ten miles. South of Posuncula river, the formation disappears, or loses the distinct character it possesses along Ocoya creek. It is probable, however, that the same series of deposits exist, but they are at a lower level, and are partially overlaid by the recent alluvial wash from the hills and granite ridges, and in the valley, by the alluvial deposits, partly of lacustrine origin. It has already been shown in the Itinerary that horizontal strata are found at many points along the base of the mountains north of the boundaries which have been given. They are found along the course of nearly all the rivers that flow into the San Joaquin. Whether these are properly but a continuation of the formation about to be described, is not yet determined.

The position of Ocoya creek will be readily seen by inspection of the map; it takes its rise in the Sierra Nevada, and flows westward, nearly parallel with Posuncula river, towards the southern part of the Tulare valley. After emerging from the granite ridges of the Sierra, the stream flows directly across the belt of sedimentary formations, and forms a very good natural section of the beds. The thickness or elevation of the series also appears to be greatest along the course of the creek; consequently it was one of the best localities for the exploration of the deposits.

Our approach to Ocoya creek was over the tops of the bordering hills, and the view presented from them was very peculiar and interesting. The eye could wander in all directions over a vast area of rolling hills in a continued series, one behind another, and differing but slightly in their elevation. The outlines were all in unbroken curves, the surfaces were rounded and smooth, and without one projecting rock or angle.

The entire absence of vegetation (there being neither trees nor shrubs) was also a striking peculiarity, and permitted all the outlines and modifications of the surface to be distinctly seen. The color of all these hills was one uniform drab or clay color, and it was so distinct that they immediately received the title of "clay hills."

Under the glare of a strong sunlight the surface presents a peculiar velvet luster, very striking and distinct. This may have been due to the dried stalks of the grasses and weeds that are found standing thickly together over some of the hills. These remains of annual plants show that these hills are probably covered with grass during the rainy season, and present a beautiful green surface. The stalks of the wild oat, that grows so luxuriantly on the hills of the Coast Mountains, were not observed here in any quantity.

The distinctness with which the ravines and water-courses on the sides of these clay hills was presented was remarkable, and afforded a good opportunity to study the action of drainage water upon such materials. Every ravine or deep gully at the base of the highest hills could be traced upwards by the eye to its various diverging channels; these expanded into a thousand distinct branches, extending to the very summits of the hills, and resembling the outspreading branches of a tree. The whole surface of the country was seen to be cut and divided in this manner by the main ravines, and their direction could be readily traced. It was very evident that all these hills were only remnants of a formerly continuous plain or gently sloping plateau, the surface of which was at a level with, or higher than, the tops of the hills now remaining. All the valleys and ravines that now traverse the formation are evidently the result of the excavating and transporting power of water. It may, at first, be difficult for the ordinary observer to comprehend how such extensive wearing away and the removal of such enormous quantities of earth has been accomplished by the simple action of drainage water. Effects of much greater magnitude are, however, visible in all parts of the world upon rocks and forma-

tions of much more enduring and resisting materials. In fact, we must refer the detailed topography of all countries to the action of water upon the frame-work of rocks that has been prepared and elevated by subterranean forces. It is only when the results are presented in a form that can be readily comprehended that they become astounding.

The materials of which this formation is composed are exceedingly light and yielding, and they are not protected by any consolidated layers of great extent. The hills, also, being devoid of trees and vegetation, are not covered by a soil or sod bound together by roots; the surface water has, therefore, free action upon the earth, and the course of its drainage is not obstructed. Under these conditions, every shower that pours down there in the winter season acts rapidly upon the soft materials, and every rivulet, stream, and torrent, in its course towards the rivers, becomes turbid with immense quantities of clay held in suspension. It is by this continually repeated action of the water that the deep valleys of the Ocoya and Posuncula rivers, and their thousand tributary ravines, each with its multiplied diverging channels, have been excavated from what was formerly an elevated and unbroken plateau. The quantity of earth that has been removed in this manner is enormous, and may be regarded as nearly equal to the amount that still remains in the hills. All this removed material has been transported down into the Tulare valley, from which a portion may have again been carried into the San Joaquin. When we consider the extent of the erosion of these valleys, we can readily conceive that the alluvial deposits of the Tulares have a very great thickness. They are very broad, and cover a much greater area than is now occupied by the lakes.

Some of the highest hills of this formation are found along the banks of Ocoya creek, where the best natural sections that were found occur. They are near the spot marked as Depot camp on the general map. The hills in this vicinity rise about eight hundred feet above the bed of the stream; and the lines of horizontal stratification are traceable from one hill to another across deep ravines.

The great inclination of the slopes of these hills is worthy of mention; many of those near our camp were so steep that it was impossible to ascend them without winding around their bases in some of the side ravines. The perfectly even surface that they present, entirely bare of rocks or vegetation of any size, renders the ascent of the steep slopes impossible. I measured the slopes of several hills with the clinometer, and found them to vary from 30° to 38°; at other points the inclination amounts to 45°. The general aspect of the hills along the side valleys is shown in View X, accompanying this chapter.

Lithological Characters.—Although by far the greater portion of the materials composing the formation are extremely light, fine, and unconsolidated, there are, in some places, layers of sandstone and conglomerate, which offer more resistance to the action of the weather than the other strata, and that slightly modify the rounded contour of the hill-sides. The principal constituent of the formation is a fine gray sand, mingled, in some of the beds, with a considerable portion of clay, and alternating with layers in which clay predominates. Volcanic materials, or sands derived from their abrasion, constitute a large part of the strata. Thick beds are formed almost wholly of white pumice-stone, in rounded masses, or in a fine powder, like fine sand, regularly bedded. The color of these beds is white, but the lines of stratification are rendered very distinct by the stains produced by the percolation of impure waters; also, by layers of the same ingredients, differing in their fineness, and by occasional seams of *charcoal*, in fragments.

Thin layers of pebbles are also numerous even among the strata of the finest materials. They show that the waters, under which the beds were deposited, were liable to considerable disturb-

Lith by A Hoen & Co Balt.

ROUNDED HILLS, TERTIARY.

ance, being sometimes comparatively quiet, and at others, thrown into currents. The thick beds of sand also present evidences of variations of current, both in direction and velocity. The inclined stratification, called *diagonal stratification*, is very common, and in many cases is beautifully shown by multitudes of the finest layers of sand, inclined in different directions, as shown in the sectional representation of the strata at *e*, Geological Sections, Sheet I.

The distinctness of these lines is caused by the difference in the sizes of the grains of sand, and by slight differences of the materials, which have become stained yellow and brown since they were deposited by the infiltration of ferruginous water from the superincumbent strata. These examples of diagonal stratification were found in the lower portions of the strata, in the hill-sides near the level of the creek. They were thus probably about eight hundred feet below the higher beds of the formation. The diagonal stratification of the lower beds, and other facts about to be mentioned, indicate that their deposition took place in comparatively shallow water.

The mineral constitution and alternation of the strata will be better understood by the examination of the section which has been referred to. This represents the succession of the strata in a vertical height of one hundred and sixty-two feet, and it is drawn on a scale of twenty feet to an inch.

The hill in which this order of the strata occurs is near the spot which was occupied as the Depot camp, and is on the south side of the creek. The upper parts of the series were not exposed to view, and are not included in the section. It is, of course, impossible to represent, within the limits of this section, the numerous lines of the strata; they are innumerable, and very regular; most of the layers, among the finer materials, being as thin as paper.

The following is a brief description of the principal beds in the series, in their order of succession, from the level of the creek upwards. The letters refer to corresponding divisions of the section.

SECTION OF THE STRATA AT OCOYA CREEK.

	Description	Feet.
a.	Fine, friable, gray sand, stained with lines of oxide of iron, and enclosing nodules of various sizes encased in oxide of iron	2.0
b.	Sand, in thin layers, stained with oxide of iron	0.6
	Gravel and sand, enclosing casts of fossils, obliquely stratified, and all strongly cemented with sesquioxide of iron	0.7
c.	Sand, stained by iron; includes a thin layer of pebbles	2 0
d.	Casts and moulds of fossil shells in sesquioxide of iron, gravel and sand; layers oblique	1.4
e.	Fine gray sand, cross stratification distinct, contains nodules of clay	24 0
f.	Fine gray sand, with an occasional layer of pebbles.—(This stratum is partly hid)	41.0
g.	Argillaceous sand, filled with small nodular masses of clay, from one-quarter of an inch to three inches in diameter	1.0
h.	Fine sand, with curved layers of oxide of iron	4.0
	Fine sand, with small, spherical and ellipsoidal masses of white pumice-stone. Thin layers of charcoal, in fragments	0.6
i.	Fine white sand, derived from pumice-stone, with intercalated layers of pumice in nodules and in powder	25.0
j.	Pumice-sand, or volcanic ashes, very fine and white, in thin strata	15.0
k.	White clay and fine sand	2.0
l.	Sand, with clay nodules	20.0
m.	Gravel and pebbles, with sand	1.0
n.	Gray sand, with layers of pebbles	20.0

Sandstone and layers of pebbles crop out at intervals on the side of the hill for fifty or sixty feet above the last stratum described. Higher than this, a harder sandstone and a layer of conglomerate is found. Still above, to the tops of the hills, the strata are completely obscured by

the covering of loose earth, derived from their degradation. Slight exposures at other places show that nearly all the materials are soft and light, without much color, and similar to the strata described in the section.

It was, however, observed that the upper beds of the formation, at other places, were generally more argillaceous than the lower.

Plates of gypsum, from two to four inches thick, were found in the bed of the creek, mingled with the debris of the formation. This mineral was also found in place, forming thin layers parallel with the stratification, in several hills not far from the one from which the section just described was taken. These plates were generally crystalline and transparent, and were sometimes combined with the fibrous variety called *satin-spar.*

From the examination of this descriptive section, it will be seen that volcanic products enter largely into the composition of the strata. They even form the greater part of beds, ten to fifty feet in thickness. The fact is significant, and leads to a consideration of the mighty exhibitions of volcanic activity that must have been nearly co-existent with the formation of the strata.

In some of the beds of fine, white pumice-sand, thin seams of charcoal were distinct. They were so numerous in some places that slabs of the sand were complely blackened by them. This charcoal was in mere fragments, generally so minute that their true character was easily overlooked; but several pieces from one-quarter to one-half of an inch in diameter were found, and in some the cellular structure of the wood was easily seen.

Stains produced by oxide of iron.—Layers, colored red by the presence of a considerable quantity of sesquioxide of iron, were abundant in different parts of the strata, and were often very thin and near together. Although these layers were generally conformable with the strata, and often marked out the divisions very clearly, I became convinced that they were generally the result of *infiltration*, rather than of original deposition. Of the correctness of this view, I considered that there was sufficient evidence in the curves presented by the layers of oxide on the vertical face of one of the thick beds of a light color, it thus being favorable for exhibiting the lines. After tracing these ferruginous layers for considerable distances in a horizontal line, some were found to bend suddenly downwards, in a curved direction, as shown in the annexed figure. They evidently followed the walls of a slight fissure, extending obliquely across the beds, and were undoubtedly formed by the gradual infiltration of ferruginous water, probably derived from the decomposition of pyrites.

DEPOSITION OF OXIDE OF IRON BY PERCOLATION.

Fig. 1.

Fig. 2.

The infiltrating fluid appears to have reached the fissure in its descent, and then to have flowed in greater quantity along its course, depositing the oxide of iron on the walls, and being

absorbed into the porous beds on each side. The gradual convergence of the lines, and their reappearance below, indicates that the intervening space was not favorable to the absorption of the fluid.

The lines have a dark brown, or iron-rust color, and show distinctly in the white, argillaceous strata. Where the oxide has accumulated in quantity, as along the fissure, the earth is closely cemented, and, indeed, becomes very hard and unyielding to the weather. The quantity of oxide is greatest along the walls of the fissure, and in reality forms a rich iron ore.

If, as we have good reason to believe, the iron solution is derived from the decomposition of pyrites, the lime of the strata plays an important part in the decomposition of the solution. Sulphate of lime is undoubtedly formed, and the iron oxide is precipitated, coloring the strata brown or red. The solution of lime, thus formed by the decomposition of the sulphate of iron, may then descend through the strata until the conditions favorable for its crystallization are obtained, and thus produce the beds of gypsum that are found in the same formation. The lime, or other substances in the beds, certainly exercise an important influence upon the deposition of the oxide of iron, as is sufficiently shown by the fact of the existence of the waving lines in strata below others that are free from all stain, and by the peculiar curved and concentric layers, as shown in figure 2, which is a faithful sketch of a part of the bank, not far from the point from which the first figure was copied. The lines of oxide in this figure resemble the grain of some of the gnarled woods, and a decided tendency to the formation of concretions, or balls, with concentric layers, is visible. A short distance beyond, the layers are nearly horizontal, and seem to form a part of the original stratification.

The resemblance of these parallel curved lines to the plications and contortions produced in soft strata, by pressure, could not pass unobserved. At first, this seemed to be their origin, for, to all appearance, the layers of oxide were the result of original deposition, and they formed a very considerable part of the strata. It is suggested that many of the apparent instances of folding and crumpling in banks of drift, or in beds of the older Tertiary, may be only the result of changes produced by infiltration. An example of contorted lines in a stratum of sand, included conformably between horizontal beds, is given by Sir Charles Lyell.[1] He describes the curves as very complicated, and as sometimes, to all appearance, enveloping a central nucleus of chalk, or clay. Similar curved layers occur around large masses of chalk, conforming to their surfaces, while the chalk rests upon horizontal layers of clay, or sand, below, without any signs of disturbance. All these appearances, as shown in the figures which are presented, are similar to those seen in the Ocoya Creek strata. Sir Charles Lyell, however, notes the presence of pebbles with the contorted layers, and is of the opinion that the curves result from pressure or lateral forces.

Additional evidence or illustration of the effects produced by infiltrating waters, holding iron in solution, was presented in the only deposit of fossil shells which was observed in the strata. They were exposed in the bank of the creek about ten feet above its level. The layer was not over sixteen inches thick, and was composed mainly of sesquioxide of iron, which formed a firm cement to the loose sand in which the shells were imbedded. All the lime of these shells has been removed by infiltration or otherwise, and the impressions of their surfaces are all that remain.

These instances of the deposition of oxide of iron in horizontal layers and in veins by infiltrating waters are exceedingly interesting, as they throw light upon the formation of deposits

[1] Elements of Geology, 5th edition, p. 134.

of iron ore in strata of various ages. The origin of the gypsum, which abounds in the strata in thin transparent plates or fibrous masses, is also shown by the phenomena. There is little doubt that the gypsum crystallizes from the solutions of lime, which must accumulate in the strata below those in which oxide or carbonate of iron has been formed. The appearance of interstratification that is presented by the gypsum is probably due to the fact that the solution, in its downward progress, meets with a retentive layer of clay or other materials, or that other conditions, favorable for crystallization, exist in some of the strata and not in others. The complete separation of the selenite from the earthy materials holding the solution is an interesting result of the action of the forces of crystallization, and must of necessity produce a condensation of the strata above and below. It is known that a separation of this kind results when water freezes in a bank of earth, thin sheets of pure ice being formed in horizontal planes, and thus elevating or condensing the earth above them. Another evidence of the correctness of this explanation of the origin of layers of gypsum in stratified deposits is found in the fact that thin seams occur in nearly horizontal planes in some of the highly inclined sandstone strata of Navy Point, Benicia. They were not found in all of the beds, and the layers frequently end abruptly against the sides of the stratum in which they occur. It was evident that they were the result of infiltration. The great deposits of gypsum which are found along the Canadian and Red rivers and on the Pecos probably have a similar origin. The sulphuric acid, in either instance, may have been supplied by springs, or by volcanic vents when the strata were submerged, or by the decomposition of other salts than sulphate of iron.

The peculiarly contorted and waved lines found in the sandstone strata at Benicia, in beds which rested conformably with others in which the lines of lamination were perfectly straight, are, without doubt, produced by infiltration, and connected with the formation of the seams of gypsum. In the Tertiary of Virginia, along the lower part of the Potomac, it is known that fossils cannot be obtained where gypsum abounds. Casts of the shells are all that remain, the lime having doubtless been taken to form the gypsum.

Fossils.—The bed of fossil shells, from which specimens were procured that have been the means of identifying this formation as Miocene, is near the spot we occupied as the Depôt Camp, and on the left bank of the creek. It was a source of much regret not only that the shells had all been dissolved out, but that the extremely perfect impressions and casts which were left in the clay and sand were so friable that they could not be transported. A person skilled in conchology could not fail to determine the species at once from these impressions, so perfect were they in every part, even to the finest lines of the former surface of the shell. A few specimens, which were more highly charged with oxide of iron than the others, were procured and transported in safety; but multitudes of the most interesting forms could not be carried away without crumbling. Being without any glue with which to saturate these specimens, the only resource was to make careful drawings upon the spot, representing, as nearly as possible, all the important characters, so that the species might be determined from them. Selections from the drawings thus made will be found on Plates III to IX. They were forwarded to Mr. Conrad, of Philadelphia, together with some of the specimens, and his report upon them will be found in full in the Appendix. Mr. Conrad considers all these fossils as new species, and has named them as follows: *Natica Ocoyana*, *N. geniculata*, *Bulla jugularis*, *Pleurotoma transmontana*, *P. Ocoyana*, *Sycotopus Ocoyanus*, *Turritella Ocoyana*, *Colus arctatus*, *Tellina Ocoyana*, *Pecten Nevadanus*, *P. catillifornis*. Casts of the following genera were identified, but the species could not be determined: *Cardium*, *Arca*, *Solen*, *Dosinia*, *Venus*, *Cytherea*.

Specimens of the genus *Natica* are the most abundant. They occur of all sizes intermediate between those represented, figure 57 being the largest one that was obtained. *Natica geniculata* is described by Mr. Conrad from the drawing of the cast of the interior of the shell, Plate VII, fig. 67. This cast, when among the others, appeared to me to be like the species represented in figures 64 and 65. Casts of this form were numerous, and the exterior of the shell was shown by the impressions of the outside to have been rugose and tuberculated. A fragment of one of these impressions of the exterior is represented in fig. 66.

Of the genera *Pleurotoma* and *Turritella* (Pl. VII, figs. 69 and 71, Pl. VIII, figs. 73 and 74,) but three or four specimens were found. The casts of the interior were very perfect, even to the end of the spire.

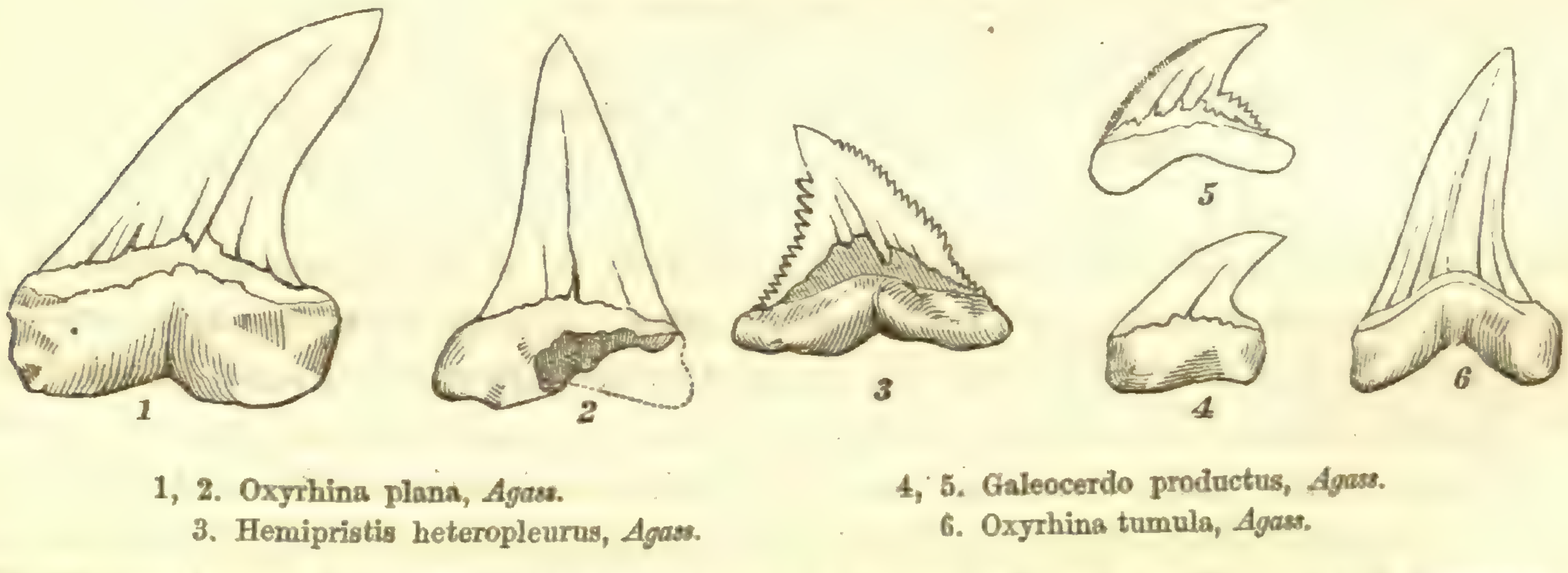
The bivalves were very abundant, and generally of large size. Forms similar to fig. 79, Plate VIII, (*Dosinia?*) and 81 and 82, (*Venus?*) were most frequently found. *Tellina* (Pl. VIII, fig 75) and others, perhaps the same species, were very numerous. The forms of both the inner and outer portions of all these bivalves were well preserved, but the valves were all separated.

One specimen only of the form shown by fig. 78, Pl. VIII, was observed. The figures represent the cast of the interior, an end view showing its convexity, also a portion of the cast of the outside. The impressions of numerous teeth along the hinge were very perfect, and they resemble those of the genus *Arca*, to which I suppose the fossil belongs.

Impressions of very large shells of the genus *Pecten* were very numerous. Species identical with, or similar to, that represented by fig. 77, Plate VIII, (*Pecten Nevadanus*) were the most common. The shells were but slightly convex, but appeared to have been very thin, and to have had very prominent ribs. The fine cast of *Pecten catilliformis*, represented on Plate IX, fig. 83, was found on a slab of sandstone, but without the impression of the exterior. It is more convex than the other species of *Pecten*, and has much larger ribs, as shown by their imprints on the margin.

Two small teeth of sharks were found imbedded with the casts of these shells; but a much greater number were obtained from the surface, on the tops of the hills, four or five hundred feet higher up in the series of beds. They were lying loosely on the ground, and appeared to have been washed out of the upper strata of light clay by the rains. They occur of various sizes and forms, some of which are shown in outline in the figures, and in full on Plate I.

TEETH OF SHARKS—FOSSIL.



1, 2. Oxyrhina plana, *Agass.*
3. Hemipristis heteropleurus, *Agass.*
4, 5. Galeocerdo productus, *Agass.*
6. Oxyrhina tumula, *Agass.*

These fossil teeth were submitted to Professor Agassiz, and his descriptions of them are presented in full in the Appendix. He observes that most of them belong to the "family of

sharks; one to that of skates, and another is remotely allied to the family of mackerels." "No fossil sharks' teeth having been found west of the Rocky mountains before, this discovery of a variety of species belonging to several genera of the family of sharks constitutes one of the most interesting additions to our knowledge that could have been obtained from that quarter; and the importance of these fossils to science is further enhanced by the peculiar relations they bear to similar fossils in the Atlantic States and in Europe, and to the sharks now living along the shores of the Old and of the New World."

These fossils all differ from known species, and are described by Professor Agassiz under the following names: *Echinorhinus Blakei, Scymnus occidentalis, Galeocerdo productus, Prionodon antiquus, Hemipristis heteropleurus, Carcharodon rectus, Oxyrhina plana, O. tumula,* and *Lamna clavata.* It appears that a species of the genus Echinorhinus is now found in a fossil state for the first time; the only hitherto known representative—the *Squalus spinosus,* of Linnæus—being found only in the Mediterranean and the Atlantic, on the European and African coasts. Professor Agassiz observes, that "the discovery of a fossil species of this genus in the Tertiaries of the western slope of the Sierra Nevada is not only important as carrying back this curious type of sharks to a period older than ours, but also in disclosing the existence upon the American continent of types in a fossil state known in the Old World only among the living. The fossil species of Echinorhinus differs from the living, having the main point of the tooth more prominent, and at the same time shorter, an appearance which arises from the less prominence of the marginal denticles."

It is also an interesting fact that while no representative of the genus *Scymnus* has yet been found in the Pacific ocean, its former existence there is shown by the specimens. Professor Agassiz also identifies one of the specimens as a fragment of a tooth of the genus *Zygobates,* of the family of *skates,* with pavement-like teeth. No species of this genus, or the allied genera, have yet been observed in the Pacific ocean. Several fragments of bone which I picked up with these teeth are identified as belonging to the family of *Scomberoides,* remotely allied to the mackerels, but they are too imperfect to be more nearly identified. Other fragments obtained at the same time are bones of mammalia, but, with one exception, they were too small and uncharacteristic to be identified with any degree of certainty. One of them is considered by Dr. Joseph Leidy, of Philadelphia, to be a portion of the crown of the molar tooth of a mastodon. Several small specimens of silicified wood were also found.

Age of the formation.—Mr. Conrad, after a careful examination and comparison of the fossil shells, considers that the formation should be referred to the middle Tertiary or Miocene He remarks that he does not find any recent species among them, nor any contained in an Eocene deposit. Professor Agassiz arrives at a similar conclusion from the examination of the sharks' teeth.

The original conditions of the deposition of these strata, so far as they are indicated by the fossils and lithological characters, are worthy of attention. The earthy materials surrounding the casts of the shells were not very fine, but consisted principally of coarse sand, mingled with pebbles, the perfection of the casts being secured by the infiltrated oxide of iron and a small portion of clay. The sand and clay had completely filled the interior of the most complicated shells, being found to have penetrated to the full length of the spires of long *Turritellæ.* The shells were mingled together very closely, and in confusion. Oblique or diagonal stratification was shown in the stratum as well as in those above, thus proving the existence of currents changing in direction. The shells had evidently been drifted to that point and accumulated by

the current, although, in many respects, the bed appeared like a beach accumulation. The valves were broken and separated, and piled in confusion, one on another, the interstices being filled with coarse sand. The shells could not, however, have been rolled on the beach or transported about in contact with gravel and sand for a very long period, as the perfection of the moulds of the outer parts was such as to lead to the belief that they had not been long exposed to attrition.

The proximity of these beds to the high ridges of the Sierra Nevada, and to the underlying granitic and metamorphic rocks, render the presence of beach accumulations extremely probable. They would, in most cases, become re-assorted and drifted to a short distance during a period of subsidence, especially if attended by sudden or convulsive movements.

We should expect to find, also, at different points along this belt of Tertiary strata, the evidences of the former flow of rivers from the mountains as at the present day. Indeed, it is most probable that the great mass of the strata is composed of materials transported to the former sea by the rivers of the Sierra. At the points where these rivers were most numerous and powerful, we should expect to find great variations in the lithological characters of the strata, and also the remains of land plants and animals. The layers of charcoal which occur, may have been, and probably were, brought down to the sea by rivers. These little fragments not only show the presence of adjoining dry land covered with vegetation at that distant period, when the whole inhabitable part of California was submerged beneath a Tertiary sea, but they, together with the volcanic ashes in which they are entombed, assure us of then existing volcanoes, in full activity, sending out streams of lava and producing conflagrations in forests long since passed away.

The remains of marine mollusca and of sharks are now about one hundred miles distant from the ocean, and separated from it by high mountains. The bed of shells is at an elevation of 750 feet above tide, and the shark's teeth were at least 1,200 feet. It is probable, however, that at other localities similar remains will be found at a much greater elevation; the hills upon which the teeth were found being much lower than many within a short distance. There is little doubt that in a few years, when the country becomes settled, and it is possible to roam over the hills of this formation at leisure, many important localities of organic remains will be found, and that it will become a favorite resort for the palæontologist.

CHICO CREEK AND VOLCANO RIDGE—VALLEY OF THE SACRAMENTO.

A very interesting deposit of fossil shells occurs on Chico creek, in the valley of the Sacramento, at the foot-hills of the Sierra Nevada. This was brought to notice by Dr. Trask in his reports, and he presented me with a specimen of the rock. It is a compact calcareous sandstone, very hard, and of a gray color. The fossils are well preserved, and are white. Most of them are fragments, and many species are thickly mingled together. The single specimen contains a *Nucula, N. divaricata*, Conrad, *Mactra albaria,* Conrad, *Tellina* ——, [?] *Natica* ——[?] and fragments of spiral shells. There are also fragments of *Dentalium* and small *Baculites.* The occurrence of the latter in this deposit is exceedingly interesting, and was first announced by Dr. Trask. Three fragments can be recognized in the specimen I obtained. They are partly exposed, and are about one-quarter of an inch in diameter, but the suture lines are very distinct.

An interesting deposit of fossils, or rather of their casts, (for all the lime has been removed,)

is also found at Volcano Ridge, in a brown, calcareous sandstone. The specimens I have do not contain a sufficient number of species to indicate, with any certainty, the period to which they should be referred. These species are, however, all different from any yet found in the Tertiary of California, and appear to be much more ancient. I am led to this view by two distinct casts of *Trigonia*, a fossil which is regarded as characteristic of the Secondary period. These casts are imperfect; but there is little doubt that their reference to the genus *Trigonia* is correct. Casts of *Leda*, *Mactra*, *Venus*, *Ostrea*, *Turritella?* and other shells are also found. The cast of the Leda is so perfect that its specific characters can be satisfactorily given. It may be known as *Leda subacuta*. [1]

CARRIZO CREEK AND THE COLORADO DESERT.

At several points along the western base of the Peninsula Sierra, between the Pass of San Bernardino and the road to the Desert, along Carrizo Creek, we find outcrops of partly consolidated strata of clay and sand. These are, in most instances, nearly horizontal, or but slightly inclined, but at one point are upraised at an angle of about 20°. The exposures are on the margin of the Colorado Desert, and generally in the valleys reaching towards the central part of the mountains. The connexion of the several exposures, although not traced between the points mentioned, is indicated by a general similarity of lithological characters and position relatively to the older rocks. The outcrops do not appear in the form of a belt of hills, as at Ocoya Creek, but are extremely low, but little elevated above the general level of the surface, and present a flat or tabular surface, not worn away into smooth, rounded hills.

The only point at which fossils were obtained was in the dry valley of Carrizo Creek, within a few miles of the open plain of the Desert. At this point the strata are nearly horizontal, and fill the space between two ranges of granitic and metamorphic rocks, forming a valley extending in a nearly northwest direction from the Desert. The valley of the creek is excavated in these strata, and their edges are exposed on each side in bluffs, generally less than sixty feet in height. These hills are generally flat, thus forming table-mounds where they are much cut by side ravines. Similar strata were found in slight outcrops on the Desert, near the dry gulleys of New River, and part way up the slope towards Carrizo Creek. They probably underlie the whole surface of the Desert, being concealed from view by the thick deposits of alluvial and lacustrine clay.

Lithological characters.[2]—The outcrop on the slope of the Desert, near the road leading to Carrizo Creek, consists chiefly of a light-colored, friable sandstone, calcareous, and rather coarse. At the upper edge of the slope, where the road turns to descend to the level of the valley of the creek, the hills or bluffs are argillaceous, and of a red color. No hard sandstone was noted. Gypsum, in thin plates, is abundantly disseminated in these strata, and, by being washed out, lies all over the surface in shining masses. All these strata are soft, and easily broken down by a shovel. Higher up the creek, these soft and red clays, or argillaceous sands, give place to light-colored or yellowish sandstone containing a large per-centage of lime, being in some places

[1] LEDA SUBACUTA: Shell smooth, convex, of a height equalling half the length; anteriorly elliptically rounded; posteriorly acute, compressed, but with a sufficiently prominent postero-superior ridge; ventral margin regularly convex; beaks moderately prominent, placed a little before the middle. Teeth crowded, but deeply separated; in number, nineteen before, and twenty-one behind the beaks; the posterior ones immediately contiguous to the beaks are very minute.

Length, 0.7; height, 0.354; breadth or thickness, 0.25 inch.

Locality: Volcano Ridge, California, in a brown calcareous sandstone.

[2] Reference is made to the Itinerary for observations upon the strata in detail.

traversed by veins of calcite. These sandstone beds differ in hardness, some being firm and apparently durable, and others friable and easily crumbled by the hand. In some of the harder beds large, spherical concretions occur. No uniform beds of conglomerate, like those found in the strata of Benicia and Monte Diablo Valley, or at Bear Creek, could be found. At a point nearly opposite the usual camping ground, on the creek, the strata were, however, composed of coarse sand and gravel rudely mingled together; but, in general, the deposits are fine, and do not exhibit the influence of powerful currents at the time of their deposition.

Another extensive outcrop of similar strata was traversed on the 19th of November, and is described in the Itinerary. These beds were remarkable for the regularity of their stratification and the number of the extraordinary concretions, of all imaginable forms, which were lying in long lines on the outcropping edges. The materials of this series are nearly all fine, being clays of different shades of brown, gray, and red. Gypsum occurs with the red strata. These strata are upraised at an angle of about twenty degress, and trend north 25° west. There was no favorable section showing the dip or the thickness of each bed, but the combined thickness, as exposed, is not less than two thousand feet.

At the northwestern extremity of the valley of the Desert, near the base of the Pass of San Bernardino, an exposure of strata, in a ravine, resembles those just described; but they are harder, and not so much disturbed. They contain a great abundance of concretions; many of them being true septaria, or flattened ellipsoids of clay, with internal cracks, filled with crystallized carbonate of lime. Nodules and concretions of peroxide of iron were also numerous, and some of the specimens appear to have been the remains of plants.

The extent of the strata of Carrizo Creek, towards the south, along the mountains, is not known; but the same series undoubtedly appears at intervals as far as the Gulf, and, probably, is extended southward along its shores. The sandy strata, which are exposed in bluffs along the Colorado, from Pilot Knob to and beyond Fort Yuma, and which also extend on the opposite shore, and along the Gila, are probably a part of the series, but have not yet been identified by fossils. They may be much more recent. These bluffs are the margins of the great desert plains, which are paved with a thick layer of pebbles—a kind of drift which has been uniformly spread out along the lower Colorado and Gila. A similar drift occurs on the tops of the mesas along Carrizo Creek. It is identified not only by a similarity in the size and general character of the pebbles, which are chiefly porphyry and black basaltic fragments, but by the presence of quantities of silicified wood, in fragments of all sizes, from an inch in length to several feet. The largest masses of silicified wood were, however, confined to the vicinity of Carrizo Creek. The pebbles, also, along the Colorado appear to be derived from a layer of conglomerate, about five feet thick, which overlies the sandy beds; while on the other side of the Desert, at Carrizo Creek, this layer of conglomerate does not appear, or was not observed.

Fossils.—Fossils were obtained from one point only near the Desert and in the valley of Carrizo Creek. They form the upper stratum of one of the flat-topped hills, and great blocks, composed entirely of the shells and their fragments, have broken off by their own weight and rolled to the foot of the short slope. The stratum is several feet thick, is very hard, and is entirely composed of shells, chiefly of the genera *Ostrea* and *Pecten*, and a little clay. Mr. Conrad recognizes, also, a species of *Anomia*, and regarding them all as new forms, has described them under the names: *Pecten Deserti*, *Anomia subcostata*, and *Ostrea vespertina*. (See Appendix, and Plate V, figs. 34, 36, 37, 38, and 41.) Dr. Heerman, the naturalist of the Expedition, in passing along the dry bed of the creek, two or three miles below, picked up an *Ostrea* much

larger than any in the bed. This is also new, and is named *O. Heermani*. It is about six inches in length. Mr. Conrad notes an analogy between these fossils and those of the Miocene strata of Virginia. The *Anomia* is allied to *A. Ruffini*, and *Ostrea vespertina* to *O. subfalcata*. He is inclined to regard the formation as Miocene. The Miocene fossils, to which he refers in connexion with these, in his letter, were from a different locality, being from the coast, at San Diego or Santa Barbara.

SAN DIEGO.

The gradual slope extending from the base of the Peninsula Sierra to the sea at San Diego appears to consist of nearly horizontal, or but gently inclined, Tertiary strata. Its upper margin, at the foot of the ridges, has a general elevation of about 1,200 feet, and its descent to the sea, fifteen miles distant, is very gradual. The streams in their descent cut canal-like valleys, with steep sides. These are very narrow, and are generally invisible from a short distance—the general aspect of the slope being that of an unbroken plain. The surface, however, and the sides of the valleys bear no resemblance to the barren and arid exposures of the formations of Carrizo Creek, on the other side of the mountains. On the seaward side, the surface is soil-covered and obscured by vegetation, and the edges of the strata along the valleys of erosion are hid by a talus of debris and earth. It therefore was not possible to determine the lithological characters of the strata with any detail. In descending the mountains from San Pasqual towards San Diego, rounded hills were observed just before reaching the slope. These appeared to be formed of horizontal strata, and were of light argillaceous sand and the debris of granite. Their relations to the strata of the adjoining slope were not determined, but they were supposed to be a part of the same series. On the road from the Mission to "Old Town," or San Diego, a slight exposure of the strata at the road-side consists of soft sandstone and clay ; principally friable, argillaceous sandstone, colored dark brown by bitumen or coaly matter. The presence of coal or lignite in the vicinity of San Diego has been several times reported, but no specimens have come under my observation.

On the left or north side of the entrance to the bay, there is a series of rounded hills rising to the elevation of 200 or 400 feet. They appear to consist entirely of soft and semi-consolidated strata ; and at the end of Point Loma, where they have been undermined by the surf, are composed of sand and pebbles, with the lines of stratification slightly inclined inland. It is doubtful whether these strata are an upraised portion of those forming the slope or a more modern deposit. A heavy dyke of greenstone extends parallel with the foot of the mountains, and at some points may have uplifted and broken the strata, but there was no good evidence of it along the road. A limited exposure of sandstone, in the banks of a small brook not far from this dyke, consisted of beds inclined at an angle of less than ten degrees. These were surmounted by a conglomerate of rounded pebbles like the shingle of a beach ; similar accumulations were noted at other points on the surface of the slope.

Fossils.—Before leaving the Mission of San Diego, a block of sandstone, filled with fossils, was handed to me, but the locality was not seen. It is a compact sandstone, not unlike that of the Bay of San Francisco and Oregon. Mr. Conrad finds it to contain the following species: *Cardium modestum*, *Nucula decisa*, *Corbula Diegoana*, *Mactra Diegoana*, *Natica Diegoana*, *Trochita Diegoana*, *Tellina Diegoana*, and *T. congesta*. He also remarks a palæontological relation between these fossils and those of Monterey, Carmello, and those found in boulders in Oregon by Mr. Townsend and Professor Dana. It is indeed uncertain whether two of the San Diego

species are not identical with Oregon forms. "*Nucula decisa* is similar to *N. divaricata*, and both, in their markings, resemble *N. Cobboldii* of the English Miocene. *Mactra Diegoana* is nearly related to the Oregon *M. albaria*." The little species *Tellina congesta* is one of the most abundant fossils at Monterey, where it covers slabs of rock many feet square. For figures, see Plate III.

BERNARDINO SIERRA AND SAN FERNANDO.

The range of hills extending nearly east and west between the valley of the Santa Clara and the plains of San Fernando is composed of uplifted strata of argillaceous sandstone. The range extends nearly in the line of prolongation of the valley of Williamson's Pass, and has an average elevation of 1,000 feet above the plain of San Fernando. There is thus a very considerable exposure of the strata, and they probably attain a great thickness.

The pass of San Fernando is, unfortunately, not a deep break or ravine through the range, made by a stream; the strata are thus not favorably exposed to view. Their lithological characters were indicated to some extent by the debris and transported blocks found in the ravines, and from them it was evident that thick beds of a very compact and even-grained sandstone occurred in the range. The strata in general, however, appeared to be soft and not indurated, being chiefly gravel, sand, and clay, principally the debris of granitic rocks.

Fossils.—The only fossils obtained from the formation were in a loose mass of the sandstone near the southern base of the Pass. The genera *Ostrea*, *Pecten* and *Turritella* are represented, but the specimens are so imperfect that they cannot be specifically identified. They are, however, sufficient to show the Tertiary age of the strata, and I am inclined to regard them as Miocene. The Eocene is very probably present at the base, and the Cretaceous may also occur. The range of hills separating the San Fernando plains from those of Los Angeles is formed of sandstone strata very similar to those of the San Fernando range, and I am inclined to regard them as of the same age. On the other side, or towards the north, the extensively developed strata exposed in the lower part of the Pass of San Francisquito, and in Williamson's Pass nearly to its summit, are so near the Tertiary formation of San Fernando, and appear to be so connected with it, that there is little doubt of their being a part of the same formation. We, however, do not find in the San Fernando range those thick strata of red argillaceous sandstone which appear in the passes. These may be referred to the lower part of the series, or may possibly be of the age of the upper Cretaceous. The interesting relations which these uplifted and folded sandstone strata bear to the adjoining granitic and metamorphic rocks, renders the determination of their age an important point. Their lithological characters and general extent are described in the Itinerary.

LOS ANGELES AND SAN PEDRO.

It is very probable that the strata of the ranges just described pass beneath the surface and form the gently sloping plains of Los Angeles and its vicinity. The surface is, however, so generally level and regular in its descent that it does not appear possible that the underlying strata are thrown into flexures or inclined at angles corresponding to those in the ranges. If the strata do extend seaward under the slope, they either become nearly horizontal, or the irregu-

larities are filled up by more modern accumulations. The nearly horizontal position of the upper strata of the slope is shown by slight outcrops at several points near the city.

At one of these outcrops, in the bank of a brook, the strata are argillaceous and sandy shales, charged with bitumen, and this substance rises to the surface in the vicinity. At another point nearer the city, and among the gently rolling hills just north of it, the strata are white, like chalk, and very tough, so that the rock can be broken out in blocks. It is very light and porous, absorbing water rapidly when wet, and emitting a strong argillaceous odor. It is principally white clay and fine sand, and does not effervesce with acids. It appeared to have been quarried, under the supposition that it contained lime.

At San Pedro, twenty miles distant, there is a fine exposure of the edges of strata in the bluff overhanging the beach. This bluff is from forty to sixty feet high, and is nearly vertical, being constantly undermined by the waves. The strata appear in nearly horizontal lines along the face of the bluff, and present a considerable difference in their lithological characters. Some of them are almost wholly formed of clay, others of soft sandstone, and others of a more compact, but fine-grained rock, formed by the mingling of the two materials. With the exception of some beds at the base of the series, they are all light-colored, and have a modern appearance. The lower beds are bituminous, and emit a strong odor of bitumen when they are struck by the hammer. This bituminous mass is thinly stratified, and is, in fact, a mass of bituminous, clay shales, which are soft and plastic where washed by the tide. They are exposed along the shore, the base of the beds being below the surface of the water, but the upper limit rising in places to a height of five feet above it. Above these bituminous shales the argillaceous beds are stained with oxide of iron, and nodular masses or concretions of the oxide protrude from the face of the bluff at many points. A short distance beyond the landing, the upper part of the beach, under the cliff, is strewn with large, tabular blocks of sandstone, of a brown color, and evidently derived from the wear of the bank. They lie piled together in considerable quantities, and resist the action of the surf very well. They are thus shown to be much harder than the other strata, which are easily washed away. The surfaces of these blocks present peculiar markings, or reticulations, which are readily recognized as sun-cracks, and are precisely similar in appearance to those found on the slabs of red sandstone in the quarries of New Jersey and Connecticut. They also resemble the deep cracks produced in the clay soils of California by the sun and air after the rainy season. It would thus appear that at the time of the deposition of this stratum of sandstone it was alternately above and below the surface of the water, and it may have formed the surface-layer of a shelving beach or estuary flat, occasionally left bare and exposed to the sun for a long time.

Among other fragments of sandstone and igneous rocks along the beach, I procured many rounded masses of a black, or brownish-black, silicious rock, which much resembled coal, or a dark, impure resin. The lines of stratification were very numerous and near together, and some of the fragments cleaved readily, parallel to these layers ; but most of them broke with a conchoidal fracture, yielding thin, sharp fragments like flint or obsidian, though not so vitreous. These masses were evidently bituminous, and were very interesting as an indication of the proximity of strata formed of the same material, for they are probably broken from an outcrop below the surface of the water. They are still more interesting from a close resemblance they bear to compact vitreous beds in the great infusorial formation of Monterey. The presence of strata of marine infusoria in the vicinity of San Pedro is thus indicated. Specimens of this

bituminous and silicious rock are in the collection, and one of them has been submitted to chemical examination. It was found to contain:

Silica.
Alumnia and oxide of iron.
Oxide of manganese, (trace.)
Lime.
Magnesia.
Sulphuric acid.
Phosphoric acid, (trace.)
Potash and soda.
Bitumen.
Water.

A thin splinter of the rock is translucent, and of a brown color, but when heated before the blowpipe becomes white, but does not fuse. The odor of bitumen is given off at the same time. Yields water and bitumen in a tube. It scratches glass readily. There is little doubt of the infusorial origin of these masses, although the organisms cannot be detected.

The edges of the strata of the bluff are not exposed in truly horizontal lines; they are slightly bent into curves of a large radius. At one point, between the landing and the mouth of the Los Angeles river, abrupt and sharp flexures occur, and indicate a considerable disturbance or lateral pressure of the beds. There is, also, the appearance of an anticlinal axis, the strata dipping each way from a point which extends out into the bay towards a small island. It is most probable that the intrusion which caused this disturbance of the strata—if it may be referred to intrusive rock—was in the first range inland, back of Los Angeles, where there is a thick dyke of trappean rock, forming the crest of the range bounding the plain of San Fernando on the south and east.

No fossils were observed in these strata, but they are probably Tertiary, and a part of the series which forms the San Fernando range. They are, probably, continuous beneath the more recent deposits of the plain, and the source of the many overflows of bitumen, called *Tar Springs* by the residents of that vicinity. The quantity of bitumen which rises to the surface is very great, and indicates the presence of considerable deposits of vegetable remains in the strata below. The beds, from which it rises in such quantity, are far below those exposed in the bluff at San Pedro. This is shown by the fact that the bitumen exudes from submarine springs, and appears in quantities upon the water many miles from the shore. These floating masses of bitumen indicate the extension of the strata for a long distance seaward; indeed, there is much reason to believe that the islands, which trend nearly parallel with the coast, are formed of Tertiary sandstone.

The probability that these strata are of the age of Miocene, is increased by the fact of the presence of Miocene fossils in the bluffs at Santa Barbara or San Luis Obispo. They were collected at one of these two places by Dr. Heerman, and probably at Santa Barbara, but it is not certain. Mr. Conrad finds them to be, "a *Mercenaria*, (*M. perlaminosa*, Conrad,) scarcely differing from a species of Cumberland county, New Jersey, (*M. Ducatelii*, Conrad,) a *Cemoria*, *Pandora*, and *Cardita*, of extinct species closely analogous to Miocene forms."[1] These were taken from bluffs along the beach, very similar to those at San Pedro. It is, however, possible that these strata are older than the Miocene.

Near the mouth of the Los Angeles river there are more modern deposits than those of the high bluff near the landing. They contain fossils differing but little, if any, from species now living on the coast, and are described under the head of Post Pliocene deposits.

[1] Mr. Conrad's letter, Appendix, Article II.

MONTEREY.

Point Pinos, the northern termination of the Santa Lucia range of the Coast Mountains, is formed of a gray, porphyritic granite, and by its hardness and resistance to the sea, forms a bulwark or breakwater for the bay. The Tertiary formations adjoin this granite on the inner side of the point, and extend for many miles inland towards the southeast. They are of different colors, generally very light, and are composed of fine materials. Several quarries have been opened in the strata near the town, and the rock is used for buildings and walls. The strata are composed of argillaceous and fine, silicious materials, so fine that the grains are not easily visible. The rock is very light and porous, and when the blocks are freshly broken out from the quarry they can be easily hewn into shape by an axe, being free from coarse grit or gravel. The colors are chiefly light-yellow, or buff of various shades, and a fawn-color or drab; some of the beds are dark-greenish black or olive-brown. A light-yellow or buff, similar to that of lithographic stone or Bath brick, is, however, the prevailing tint. In density the rock is somewhat similar to Bath brick or the biscuit-ware of the potter, and, like both, it rapidly absorbs water when dry. The large Court-house, built by Walter Colton, and the church, erected in 1794, are constructed of this stone, and the sharp edges and angles which are retained by the blocks in the walls of the latter show that the material has great durability in that climate, and is well adapted to purposes of construction.

Some of the darker strata, though indurated and apparently without any volatile constituent, are *bituminous*, and give off an empyreumatic odor when heated before the blow-pipe flame. It is most probable that this bitumen is of animal origin, and its presence would not be suspected on examination by the eye merely.

These light, porous rocks form the principal part of the hills in the vicinity of the town, and extend towards the Bay of San Carlos and the Valley of the Carmello. The Mission of San Carlos, near the mouth of the Carmello, is built of them. These strata are probably near the base of the formation at Monterey, and rest directly upon the granite. No coarse materials were observed, but at the Bay of San Carlos there is a coarse conglomerate in thick beds, which appears to adjoin the granite and may underlie the softer and finer strata, but they were not seen in proximity, and it is doubtful whether the conglomerate is not much more recent in its origin.

Higher up in the series of strata, and at the summits of some of the hills, we find a most remarkable series of chalk-like beds, which consist, in great part, of the remains of silicious infusoria. The strata attain a great thickness, and are probably the most extensive and interesting deposit of marine microscopic organisms hitherto discovered.[1]

The principal outcrop, so far as yet known, is visible from Monterey and the anchorage of the bay, and appears as a white spot in the side of a hill about two miles from the centre of the town. This hill attains an elevation of over 300 feet above the bay,[2] and is separated from it by a broad, sandy plain and a belt of sand-hills along the beach. Groves of oak are found around the base of the hill, but towards its top it is covered with a dense growth of *chamizal*, (shrubbery,) through which the outcrop of white earth can be seen from a distance. The principal outcrop is an exposure 100 feet in length by from 15 to 40 in width, and it is seen to

[1] A notice of this deposit was communicated to the Academy of Natural Sciences of Philadelphia, in April, 1855.—See Proceedings. It was also described at the meeting of the American Association, in Providence, 1855.

[2] In the notice of this deposit the elevation of the hill was stated as 500 or 600 feet. I have reason to conclude that this estimate was two high.

extend much further in all directions under the vegetation. The white, chalk-like earth contrasts strangely with the green leaves above it—it seems as little fitted for vegetation as a lime heap. The removal of the loose fragments lying upon the surface revealed the existence of numerous lines of stratification as thin and regular as the leaves of a book. This white outcrop appears to be the principal or thickest stratum of the series, and it is near the top of the hill, but lower down, the white earth alternates with silicious beds, which are peculiarly compact and very finely stratified. Some of these layers are excessively hard, and the rock breaks with a conchoidal fracture, like flint or semi-opal.

The whole series of strata are parallel, but not horizontal, being inclined in a direction south of east, or nearly southeasterly, at an angle of from twenty to thirty degrees. The following is the succession of the beds, from the upper stratum downwards to the lowest point which was examined. The thicknesses given are approximations:

SECTION OF INFUSORIAL STRATA AT MONTEREY.

		Feet.
1.	White silicious earth, light, and charged with infusoria	50.0
2.	Compact and silicious, probably bituminous	.3
3.	White and earthy, resembling No. 1	1.0
4.	Compact, silicious, dark-colored, and bituminous	.6
5.	White and earthy, like No. 1	12.0
6.	Compact, silicious, dark-colored, and bituminous	.6
7.	White and earthy, like No. 1	2.0
8.	Compact, flint-like, very hard, and nearly white. No very thin layers	2.0
9.	White, earthy, and silicious, like No. 1. In very thin layers, intercalated with thin sheets of compact and semi-opaline silica	10.0
10.	Compact and silicious. Hard and drab-colored	3.0
11.	White and earthy, similar to No. 1. (The thickness of this stratum was not ascertained; it extends downwards under the chamizal for a long distance.)	——

It will thus be seen that there is one bed of microscopic organisms fifty feet in thickness. This is believed to be much less than it is in reality. The underlying beds, which are similar in their appearance, are probably equally fossiliferous; but this has not been demonstrated by examination. Their thicknesses are, respectively, 1, 12, 2, and 10 feet, which, added to the thickness of the upper stratum, make a total of seventy-five feet. This is exclusive of the compact silicious strata, which are presumed to be also fossiliferous.

The white infusorial earth contains much clay, and is very tough. It is easily cut or carved into any form with a knife, and may be sawn into square blocks with great ease. Unless crushed to powder on the surface, it does not soil the fingers. It absorbs water rapidly, but does not easily break down in it, or soften like clay.

A fragment of the upper stratum was forwarded to Professor J. W. Bailey, of the United States Military Academy at West Point in 1854; in his letter of acknowledgment, he states that it is "rich in marine diatoms; the seive-like discs belong to the genus Coscinodiscus, but there are many other very beautiful forms present. It is singular that the deposit contains some species which have only recently been detected as living species in the Pacific. It has quite a modern look, and contains many species which could only have grown in shallow water."

A full series of specimens was obtained, and, together with one large block of the white earth, was placed in the hands of Professor Bailey for examination. He has found many very interesting forms, but his observations on them have not been received. Figures of many, drawn by Professor B., will be found on Plate XII.

The compact silicious layers, intercalated with the porous infusorial earth, are very peculiar.

The rock of some of them is like semi-opal in density and lustre. The fracture is also similar, being curved; and the surface and edges vitreous in their appearance, like glass. Their color varies from white to drab, or fawn color, and is sometimes pink. Thin layers or lines of stratification are visible in all of them. Silica is the chief constituent, and it was probably deposited in an impalpable or gelatinous form. Many of the specimens resemble, in their texture, the water-worn masses which were picked up on the beach at San Pedro; but none of the layers were so dark-colored or highly charged with bitumen. These dark silicious masses of San Pedro are, without doubt, from a similar series of infusorial strata, and the deposits are doubtless connected or synchronous in their origin. This is rendered almost certain by the discovery of a deposit of the white earth at San Luis Obispo, which contains forms almost identical with those of Monterey. A specimen, obtained from the locality by a friend, has been forwarded to Professor Bailey.

The strata near the town, which are quarried into for building stone, are also fossiliferous; the surfaces of many of the slabs, when they are split parallel with the numerous lines of stratification, being found to be covered with innumerable impressions and casts of small bivalve shells. These lie thickly together, and sometimes one within the other, as if they had fallen to the bottom in quiet water, or rather, had been left bare upon a shelving beach of fine clay. The most abundant fossil is the small *Tellina*, which Mr. Conrad describes as *T. congesta*. It occurs in a similar rock at San Carlos, or in the valley of Carmello creek, and is associated with a *Lutraria*, *L. Traskie*,[1] (Plate III, fig. 23,) and impressions of very small crabs, too obscure to be identified.

A stratum of the Monterey rock, similiar in its texture to that used for buildings, but differing in color, being dark olive-brown, also contains the casts of *Tellina Congesta* in great numbers. They cover square yards of the surface of flat layers.—(See figs. 21 and 14 *a* Plate III.) This abundant fossil occurs also at San Diego with the Miocene fossils.

In addition to the *Tellina* and *Lutraria*, these rocks are charged with innumerable and beautiful *Polythalamia*, lying in thin layers through the stone and becoming visible by their numbers in white lines on the edges of the slabs. They may be seen by the unassisted eye, but their forms cannot be traced without the microscope. They are very white and perfectly preserved, and are exceedingly beautiful objects for microscopic examination. The clay in which they occur is so firm and indurated that it is very difficult to detach them for study; every cross-fracture of the rock presents innumerable sections, and occasionally the full form of a shell is visible on the surface. It is this dark-colored rock which gives off a bituminous odor; but it is not like the bituminous masses of San Pedro, which are composed chiefly of silex.

GREAT BASIN.

The stratified formations of sandstone and sandy clays, observed at different points within the limits of the southern part of the Basin, are doubtless Tertiary, but, from the absence of a sufficient number of fossils, it is not possible to affirm positively on this point, or to indicate the probable division of the Tertiary to which they may be referred.

The only fossils found were the silicified stems of plants described in the Itinerary, Chapter V., page 36. They occur in the upraised sandstone strata of the eastern end of the Cañada de las Uvas, where it opens out upon the slope of the Basin. The fossils are sufficient to show the comparatively recent origin of the strata, but, being entirely new, and of undetermined affinities,

[1] By permission of Mr. Conrad, this species is dedicated to Dr. J. B. Trask, who collected it.

do not serve to identify the strata with known formations. These fossils are not only interesting and important as the only evidence (aside from lithological characters) of the modern origin of the strata, but have peculiarities of structure of great interest to the botanist and student of fossil vegetation. Similar fossils were obtained from a silicious boulder on the banks of Posuncula River, on the other side of the Sierra Nevada; on comparison, they appear to be identical in structure, although differing so much in color and appearance as to leave no doubt of the existence of two localities.

In the Great Basin the stems form beds, with a combined thickness of several feet, lying interstratified conformably with the strata on each side. The beds are almost wholly composed of the stems; they are closely matted together and twisted in various directions. Their color is a light bluish-gray, and they are completely silicified so as to preserve every cell and fibre with perfect distinctness. The specimens from Posuncula River, being rather larger and less compressed, were selected for examination, and slices across the stem were ground down thin and polished by the lapidary. These were submitted to Professor Bailey for his examination, and he prepared an elaborate figure showing the structure.[1] It was accompanied by the following explanation:

"The plants, as far as I can make out the structure, are annual shoots of an exogenous structure, presenting a distinct pith, (*p.* in the drawings); medullary rays (*r*); a layer of liber (*l*); and a loose succulent bark (*b*), having large lacunæ (*la*). In the outer portion of the wood a series of large vessels, v 1; of smaller, v 2; and of still smaller ones, v 3, are placed. I could not detect upon these vessels any indications of spiral or dot.

"The specimens from the east slope of the Sierra agree in all essential points with the above, the only difference noticed being the development of a few large vessels surrounded with woody fibre within the pithy portion.

"I cannot venture with the limited data furnished above to form any opinion upon the affinities of these plants.

"The vertical section, fig. 1, is made up from observations of various splinters from different parts of the plants which I encased in Canada balsam. The horizontal section, fig. 2, is from the section made by the lapidary in New York, which I afterwards rubbed down to half the thickness the lapidary had given. The section thus obtained was as perfect as if from a recent plant. It showed the cells filled with transparent silica, and in the larger lacunæ the arrangement of the silica into small spherical agates was distinctly visible."

The lithological characters of these strata are given in detail in the Itinerary, Chapter V. They consist, for the most part, of coarse-grained sandstone and conglomerate, and are upheaved at an angle of fifty-four or fifty-five degrees, and trend northeast and southwest. An intrusive rock is found in the vicinity. Outcrops of uplifted sandstone also occur as far as the summit of the Cañada de las Uvas, which, however, is but little elevated above the general surface of the Basin. As these outcrops occupy the re-entering angle between the end of the Sierra Nevada and the Bernardino mountains, they are within the limits of the Basin. The outcrops near the summit may be near the source of the Eocene fossils found at the entrance of the pass on the western slope. We are thus led to suspect that they are of the age of the Eocene.

About twenty miles east of the outcrop containing the stems, and near to the entrance of the Pass of San Francisquito, there is another interesting exposure of upraised strata, but they are very different in their lithological characters. A great part of the formation is of fine materials;

[1] See Appendix, Article V.

but several very thick beds of conglomerate and breccia of porphyry, and other volcanic rocks, overlie them. A section will be found on page 56.

The sedimentary formations of the high valley of Lake Elizabeth, being on the north slope of the Bernardino Sierra, are also within the Basin, and are separated from the upraised strata just described by a long but low ridge of granite. The strata in the valley are horizontal, and composed of coarse, gray sandstone. They form a line of hills, with rounded, soil-covered surfaces, so that the strata are not well exposed to view.

A range of sedimentary hills is found throughout the chain of high valleys extending parallel with the Bernardino Sierra on the north, and at times they form the only ridge of separation between the valleys and the slope of the Basin. Thus, in passing from Lake Elizabeth towards Williamson's Pass, hills composed of horizontal strata are either found in the valley or upon the left, nearly to the Pass, when they become low and gradually disappear under the slope. Beyond this, however, and opposite the entrance to the Pass, there is a wide area of rounded hills, which, in all probability, are a continuation of the same deposits. The strata at all these different points do not present the same lithological characters. Those near Lake Elizabeth are more firm and compact, and contain beds of hard sandstone. Those nearer to the Pass are more argillaceous, and less firmly consolidated. At one point, beds of white, red, and greenish clays were observed; the white being the debris of white feldspathic granite. Gypsum was also seen in thin sheets. These formations have considerable resemblance in their external aspect to the lower hills of the Miocene deposits of Ocoya creek.

Although the topography, and several slight exposures of the strata, indicate their horizontal position, one or more outcrops were highly inclined, a dip of seventy-five degrees being observed at the eastern point of the low range separating the Basin slope from the mountains. This may be a local disturbance, or an older series of strata. Near the lower ridges of the mountains, at the Pass, there are hills and outcrops of hard strata of sandstone and a thick bed of breccia of volcanic rocks, porphyries, and the like, the fragments being from eight to twelve inches in diameter, and closely packed together. These strata incline northeasterly at an angle of twenty degrees, and dip away from a dyke, or ridge, of igneous rocks. They appear to underlie the less firmly consolidated, and probably horizontal, strata lower down the slope. No break or want of conformity was observed.

Further east, along the base of the mountains, outcrops of other strata are seen in the banks of Cottonwood Creek. They do not resemble, lithologically, either of the outcrops which have been described. They consist of the fragments and fine debris of granitic rocks, and have a red or pinkish color, due to the presence of a large portion of pink feldspar. A somewhat similar rock was seen in the Cañada de las Uvas, and occurs again in the Cajon Pass. At the last mentioned place the strata are greatly developed, and form high hills, conspicuous for their peculiar forms, due to the action of the weather. They are inclined at an angle of forty-five degrees both in the Pass and along the banks of Cottonwood Creek; and the similarity of their lithological characters is such as to lead to the conclusion that they had a synchronous origin. Both localities are free from indications of fossils; and the coarse materials indicate the rapid formation of the beds under the action of swift currents.

Other sedimentary deposits were observed along the Mojave River, at the point where the road first crosses the stream, and beyond, towards the end of the valley, in the Soda Lake. These deposits are soft, marly clays, or clay and sand, of light colors, but sometimes bluish and red. They rise in high banks along the lower parts of the river, and are worn by the weather

into fantastic forms. Indications of horizontal argillaceous strata are also found around the bases of several of the "Lost Mountains."

High, rounded hills, evidently sedimentary, were visible several miles north of the entrance to the Tejon Pass from the Great Basin, and strata of different colored clays were exposed by a land-slide, or deep erosion, produced by a sudden fall of rain. These strata attain a great thickness, and may be of the age of those seen near the summit of the Cañada de las Uvas. It is also probable that they produce the beds of salt which are resorted to by the Indians from the Tejon.

These brief descriptions of the chief exposures of the sedimentary formations of the southern part of the Basin are sufficient to show the great diversity in their lithological characters, and the difficulty of grouping them correctly without further explorations, and the collection of fossils. We may, however, separate them, lithologically, into four groups, or divisions: 1st. The soft, unconsolidated strata of variously colored clay and sand, or clay and sand mingled together, forming rounded hills, with the strata generally horizontal; 2d. The compact sandstone and semi-consolidated argillaceous strata; 3d. The sandstones and thick beds of breccia of volcanic rocks, upheaved so far as seen; 4th. The coarse-grained granitic sandstone of the Cajon and Cottonwood Creek.

I would include in the first group the soft strata on the east base of the Sierra Nevada, near Taheechaypah Pass; the strata in the Cañada de las Uvas, just beyond the summit; those near the entrance to Williamson's Pass, and in its vicinity; and the strata bordering the Mojave, along the lower parts of its course. In the second group we may include the compact sandstones of the valley of Lake Elizabeth, supposed to be horizontal, and the upraised strata in the eastern part of the Cañada de las Uvas, containing the fossil stems. It is possible, also, that the nearly horizontal strata underlying the superficial accumulations of the slope of the Basin, at the entrance to the Tejon Pass, have similar lithological characters. I include in the third group the outcrops of breccia and conglomerate on the margin of the Basin, north of Lake Elizabeth, and at the entrance to Williamson's Pass. It is probable that strata similar to these will be found at other points. These divisions are, of course, merely temporary and for convenience of description.

It is most probable that the strata of the first group will be found to be of the age of the Pliocene or recent Tertiary. They are more recent than the other groups, the age of which cannot be closely determined, although probably Miocene, or Eocene, or both.

The outcrops along the northern base of the Bernardino Sierra, including those of the Cañada de las Uvas, have an average elevation of 3,500 feet above the sea; that near Taheechaypah Pass must be nearly 4,000, and those along the Mojave from 1,100 to 2,600 feet.

We may conclude that the greater part of the surface of the southern part of the Basin is underlaid by the extension of these strata under the more recent accumulations which form the slopes. This is indicated not only by the outcrops along the Bernardino Sierra, but by those of the Mojave River, and around the detached ridges between the Mojave and the Sierra Nevada. It is probable that the strata of the Cajon Pass and its vicinity (those of the fourth group) are in a great measure local and do not extend far from the mountains. The materials do not appear to have been transported from a distance, or to have been long agitated together under water. The rock probably accumulated in the vicinity of, or around, a coast of granitic rock, which was abraded with great rapidity.

POST-PLIOCENE DEPOSITS OF MONTEREY, SAN PEDRO, AND SAN DIEGO.

Evidences of a comparatively recent or Post-Tertiary elevation of the California coast are found at various points from San Francisco south to San Diego. At San Pedro, near the mouth of the Los Angeles River, a low bluff, or bank, about thirty feet high, consists of beach-sand and shingle, mingled with shells, similar to those now living in the waters of the Pacific. Accumulations of the same kind are also found at Santa Barbara and San Diego.

The bank at San Pedro is composed, at the base, of coarse, brown sea-sand, interstratified with fragments of shells; but the upper portions are formed of coarser materials, in two or three layers, from four to six feet thick. The upper layer is of soil and sand, charged with fragments of *Pecten;* below this, a thick stratum of sand is filled with shells and a layer of fragments of a calcareous rock, or soft limestone, perforated in every direction by boring mollusks. Beach-shingle and sand, with shells, are found below. These fossils were all remarkably well preserved; but had evidently been subjected to much wearing upon a beach, as the fragments were very abundant, and many of the shells were broken.

The following species were obtained: *Tellina Pedroana*, *Venerupis cycladiformis*, *Saxicava abrupta*, *Petricola Pedroana*, *Schizothœrus Nuttalli*, *Mytilus Pedroanus*, *Penitella spelœum*, *Fissurella crenulata*, *Nassa interstriata*, *N. Pedroana*, *Strephona Pedroana*, *Littorina Pedroana.* These were all determined and described by Mr. Conrad, who observes in his letter that "the shells are generally those which live in the adjacent waters, and indicate little, if any, change of temperature since their deposition. The littoral character of this formation is very evident. Water-worn shells and fragments show the action of the surf, whilst entire specimens of bivalves, and *Pholadidœ*, and *Saxicavœ*, remaining undisturbed in their self-excavated domicils, exhibit the same disposition of marine shells that is familiar to the observer on all sandy and argillaceous shores. They burrow in clay, mud, or sand, beyond the ordinary action of the surf; whilst some are scooped out by the tempest-driven surge, and others preyed upon by fishes and marine animals of various kinds, and are thus broken up and deposited among the living species."

The action of the surf at the base of this bank has liberated great numbers of the fossils, and they are to be found strewed along the beach, mingled with shells recently cast up by the waves.

A tooth of the mammoth was also obtained from this bank by a brother of Captain Ord, of

TOOTH OF THE MAMMOTH, (lower molar, one-third natural size.)

the United States Coast Survey. It is a lower molar, weighing eight pounds, and twelve inches long. It has a grinding surface five and a half inches long, which exposes the ends of eight

plates. This surface is perfectly smooth and polished, and looks as if it had been used for mastication but recently. It is reported that more teeth and a portion of the skeleton have been found several miles in the interior, towards Los Angeles.

The shells at Santa Barbara are found in a similar bank, but only one species was obtained—a large *Crepidula,* (*C. princeps*, Conrad.) Plate VI, figs. 52 and 52*a*. This, in color and general appearance, is like the fossils from San Pedro, but it is a very large species and a beautiful fossil.

The evidences of a recent elevation are very striking at Monterey, where beach accumulations may be seen resting upon the water-worn surfaces of the soft Tertiary rocks at the quarries, a long distance from the bay and many feet above it. The shingle contains pebbles or rounded masses of the rocks below, and the surfaces of the latter are not only rounded and worn into hollows and grooves, but are perforated by boring shells. The cavities made by the shells still remain, and are filled up with sea sand. Beach-shingle was also found on the top of the hill, formed by the beds of infusoria. This includes pebbles of granite (probably broken from Point Pinos or a part of that range) and masses of the underlying silicious beds, all of them rounded and water-worn. One of these masses, softer than the others, had been perforated by a *Pholas*. This beach formation is now about 300 feet above the bay, and shows a very recent elevation. Bones of *Cetaceans* are said to be found on the opposite shore of the bay, about ten miles inland from Santa Cruz. They are reported also from many other points along the coast, but high above the sea level. According to Rev. Walter Colton,[1] they are found near Livermore's rancho, on the top of a mountain overlooking the valley of the San Joaquin.

The general appearance of the coast favors the conclusion of a recent upheaval, for the high hills and mountains are almost everwhere flanked by a slope, which, by its uniform acclivity, reminds one of an ocean beach. It is believed that careful examination will show the existence of ancient beach-lines at the upper margin of these slopes. The occurrence of beach-shingle overlaying the bituminous strata northwest of Los Angeles has been mentioned; similar accumulations were afterwards noticed in other places. It is interesting to observe, in this connexion, that a depression of the land in the vicinity of Los Angeles, to the extent of 1,000 feet, would cause the submergence of a wide area, and carry the shore-line many miles inland, so that the bend of the coast would conform to the base of the mountains as far east as the mountain of San Bernardino. With the exception of a slight and isolated elevation, which forms the headland of the open bay of San Pedro, and a range of low hills between San Bernardino and the coast, there is no elevation of any consequence between the present beach and the base of the mountains; so that a depression to the extent indicated would submerge the whole slope.

GENERAL OBSERVATIONS ON THE TERTIARY FORMATIONS.

We see by the foregoing description that the principal localities which have been identified as Tertiary are separated by wide intervals along the line of the survey, and that they present a diversity in their lithological characters and organic remains. The sandstone formation of San Francisco, Benicia, and the vicinity, having been previously described in Chapter XII, has not been considered in this general view of the Tertiary deposits. It forms another and a distinct group, lithologically, from those that have been described.

The lithological differences between the strata of the different localities are such that it would

[1] Three years in California; p. 385.

be difficult, if not impossible, to trace the connexion of the formations without the aid of fossils. Even the fossils have very different aspects, and present a different grouping of species at each locality. The difference in mineral characters, which apparently is so great, is, no doubt, in part due to the limited examinations which have been made; and it is probable that more extended explorations will show that each well-marked group of strata has a wide extent along the coast. The distances between the localities described, and the different positions of the strata relatively to the great lines of elevation about which they were deposited, are also sufficient to lead us to expect the strata, even of the same age, to be very different in their appearance. The Miocene strata of Ocoya Creek are about eighty miles removed from those of San Fernado—supposed to be also Miocene—and a range of mountains, with the lowest passes over three thousand feet in elevation, extends between them. One series of strata is at the eastern base of the Sierra Nevada, the other at the southern base of the Bernardino Sierra. The outcrops at San Fernando are one hundred and forty miles distant from those of San Diego, and those of San Diego fifty miles or more from the fossiliferous strata of Carrizo Creek, and on the opposite side of the high Peninsula mountains. So, also, the strata of the Great Basin are separated from the other localities by mountains on all sides.

Although we fail to trace a resemblance between the strata of the same age over the whole extent of the region which has been considered, it is believed that the strata which are developed at distant points along the same base of either of the great mountain ranges have a general similarity of mineral contents; in other words, the great lithological differences of the strata are coincident with the great variations in the relief of the surface, and are also found on the opposite sides of the same chain of mountains.

There is little doubt that formations of the age of those of Ocoya Creek, and bearing a general resemblance to them in mineral composition, extend along the whole western base of the Sierra Nevada, although interrupted at many points, or removed by denudation and the action of rivers. The rounded hills passed on the 21st of July, and described in the Itinerary, are believed to correspond in age with those of Ocoya Creek. So, also, thick horizontal strata at Mokelumne hill, composed, in great part, of volcanic ashes and pumice; and strata found at several points further north are probably of the same period. The deposits of Chico Creek, represented by Miocene fossils, are, perhaps, a continuation of the same series, but may be, and probably are, older, or lower in the group than those of Ocoya Creek. Dr. Trask has noted the occurrence of marine fossils at Willow Springs and other points in the Sacramento Valley.

The deposit at Volcano Ridge, so far as it is represented by the specimens in hand, does not appear to be of the same series, but is, apparently, older.

The Miocene deposits are not confined to the base of the Sierra Nevada, but are found on the opposite side of the valley at the base, or forming the foot-hills, of the Coast Mountains. They were, also, found at the extreme southern end of the Tulare Valley, resting upon the upturned edges of the older sandstone (probably Eocene) near San Amédio.

That these are Miocene, or more recent, is not only indicated by their unconformity with the supposed Eocene strata, but by fossils of the genera *Meretrix* and *Stramonita*, found near the foot-hills. Mr. Conrad regards these as Miocene, and describes them as *Meretrix Tularana* and *Stramonita petrosa*. A fine specimen of the genus *Arca*, described as *Arca microdonta*, (Plate III., fig. 29,) was obtained from the hills of the Coast Mountains near the Tulares. This is regarded as Miocene by Mr. Conrad, who states that it has some resemblance to *A. arata*, Say, of the Maryland Miocene.

The relation of these Miocene deposits to the recent *drift*, or the *auriferous drift*, of the slope

of the Sierra Nevada is obscure for want of sufficient explorations and examination. These more modern accumulations attain such a great development, and are frequently of such fine materials, including, also, volcanic sand and ash, fragments of pumice, and the like, that they might easily be mistaken as the equivalents of the Ocoya Creek series. Whether the horizontal strata, seen near the Tuolumne, at Fort Miller under the basalt, at Bear Creek, (see Section 2, Sheet I,) and at the crossing of the Chowchillas, can be referred to the Ocoya Creek series, or are much more recent, can only be determined by fossils or further exploration, so as to trace the continuity. The strata in the vicinity of the Tuolumne and the Merced rivers, forming the flat-topped hills, were, at the time of their examination, supposed to be the equivalents of the sandstone strata of the Coast Mountains on the opposite side of the valley.

The Miocene strata of San Diego are, without much doubt, extended northwards along the whole slope of the Peninsula Sierra, and connect with those which appear in outcrops at San Fernando and other places. The strata of all this slope may be regarded as one group, and are believed to have a general similarity of lithological characters and fossils.

A great difference is, however, presented between the strata of San Diego and those on the opposite side of the mountains, although they are probably synchronous in origin. The high Peninsula Mountains were, doubtless, a barrier between the seas at the time of the deposition of the strata, as, at the present day, they are between the waters of the Gulf and the Pacific. There is also a remarkable difference in the appearance of the fossils from the east and west sides of the chain. While on the Pacific side we find a variety of genera and species, both of univalves and bivalves, the deposit on the eastern, or Gulf side, consists of an enormous bed almost wholly formed of *Ostracea* and *Pectens*. Although an entire separation of the Miocene seas is indicated, it is probable that they were connected, during a part, at least, of the Tertiary period, through the pass of San Bernardino; Lower, or Old California, being thus left as an island, which it was formerly supposed to be. A depression of only 2,808 feet would be sufficient to again unite the head of the Gulf with the Pacific, and thus form an island of the Peninsula.

The San Francisco sandstone is probably co-extensive with the Coast Mountains north and south—south as far as the Bernardino Sierra, and north even into Oregon and Washington Territories. There is much reason to believe that the coal beds of Bellingham Bay and Puget's Sound occur in this series of strata. A block of sandstone from the coal strata of the former place is nearly identical in its mineral constitution and appearance with that of the vicinity of San Francisco. It contains two large *Pectens* and masses of coal.[1]

The southern extension of the great deposits of microscopic, silicious organisms at Monterey is shown by the specimen from the vicinity of San Luis Obispo, and by the rolled silicious masses charged with bitumen, and of undoubted infusorial origin, which are cast up by the surf on the shores of San Pedro.

Although the observations which have been made are comparatively limited—if we compare them with the great extent of surface of California—they are sufficient to show that the Tertiary attains an enormous development on the Pacific coast; and that, in fact, a large part of the area of the State is either occupied by, or underlaid by, strata of that period. They probably constitute the principal part of the ranges of the Coast Mountains, where they attain their greatest development and thickness. It is not yet possible to form a reliable estimate of the thickness of the whole series of strata, but exposures at several points are not less than 2,500 or 3,000 feet.

[1] A descriptive section of the coal-bearing strata is given in Chapter XIX.

CHAPTER XIV.

OBSERVATIONS ON THE TULARE VALLEY.

DESERT-LIKE ASPECT OF THE TULARE PLAINS.—SLOPES NEAR THE MOUNTAINS.—THE VALLEY DISTINCT FROM THE VALLEY OF THE SAN JOAQUIN.—EXTENT OF THE VALLEY.—ASPECT OF THE COAST MOUNTAINS.—SURFACE AND SOIL OF THE VALLEY.—CLAY SOIL.—ALLUVIUM.—MIRY SOIL BETWEEN KING'S RIVER AND THE FOUR CREEKS.—GRAVELLY SLOPES AROUND THE MOUNTAINS.—CLAY OR ALLUVIAL SOIL OF THE LOWER PART OF THE VALLEY UNDERMINED BY BURROWING ANIMALS.—FRESH-WATER SHELLS.—COTTON-WOOD TREES.—TULE.—VEGETATION AT THE MOUTHS OF THE RIVERS.—QUANTITY OF WATER IN THE LAKES.—COMMUNICATION WITH THE SAN JOAQUIN.—SALINE INCRUSTATION.—FORMER SUBMERGENCE OF THE VALLEY.—GREAT RAPIDITY OF EVAPORATION.—EXPERIMENT TO DETERMINE THE AMOUNT.—RESEMBLANCE BETWEEN THE TULARE VALLEY AND THE VALLEY OF THE COLORADO DESERT.

It is difficult to conceive of the great extent and desert-like character of the Tulare Valley without having travelled for days over its surface, beyond the sight of trees or green grass. It appears to be almost a perfect plain, but slopes gently away from its bordering mountain ranges, the descent becoming more gradual and imperceptible as the distance from the mountains is increased. Although this valley is a portion of the great longitudinal valley of California, occupied by the San Joaquin and the Sacramento rivers, it is, in a measure, isolated from the latter, and has its own system of streams and lakes that do not, at all times, communicate with the San Joaquin. We may, therefore, regard and describe it as a basin-shaped depression, distinct and separate from the Valley of the San Joaquin, although, in respect to the general relief of the surface, it is merely a continuation of it. The San Joaquin, when it descends the slope from the mountains, bends to the north until it meets the water of the Sacramento, but the rivers south of the San Joaquin, and which, like it, rise in the Sierra Nevada, turn southward, and are not its tributaries. The slightly elevated ground between the San Joaquin and the lower surface southward may, then, be regarded as the northern boundary or margin of the Tulare Valley. Its length from the San Joaquin River (latitude 37°) on the north, to the high range of the Tejon Mountains on the south, is about 150 miles. Its breadth, or the distance between the Sierra and the Coast Mountains near latitude 37°, is about 70 miles. Towards the south it becomes narrower, but may be said to have an average breadth of 50 miles. Its area is thus about 7,500 square miles.

When standing on the eastern side of the valley, near the hills at the base of the Sierra Nevada, the Coast Mountains are just perceptible in the distance; but the distinctness with which they can be seen varies greatly with the purity of the air. They have a barren aspect, and do not appear to have any verdure.

Surface and soil of the Valley.—South of the banks of the San Joaquin the character of the soil changes from the loose, gravelly, granitic debris, and becomes more compact and argillaceous. This change is most apparent at King's River, where the character of the substratum of the plain is visible in the banks of the stream. A large amount of clay enters into its composition, and it has a decidedly alluvial appearance, being much finer and more argillaceous than the banks of the streams that enter the San Joaquin.

Between King's River and the Four Creeks the soil consists almost wholly of clay, and its

miry nature during the wet season has been noticed. (Chapter III.) South of the Four Creeks the portions of the valley near the foot hills have a gravelly and sandy surface, apparently formed by the wash from the adjoining high grounds. The gravelly character is observable at the slopes of the Tejon and the vicinity of the ridges of the Cañada de las Uvas, and it is probable that the valley is surrounded by a belt of coarse soil, flanking the mountains. Its central portions have a finer and a more clayey character, which naturally results from the decrease in the velocity and transporting power of the streams as they pass from the high slopes near the mountains to those of a more gentle inclination lower down. All the central parts of the valley have an alluvial aspect, and at the time of my visit, in August, the soil was extremely light and dusty. It was also completely undermined in all directions by thousands of burrowing animals, (rabbits and squirrels,) so that the feet of my mule were continually breaking through, rendering it extremely difficult to proceed, and dangerous to travel faster than a walk. The animals often sank suddenly up to their shoulders in these places.

The clay has a gray or bluish-gray color, and seems to have been deposited by water; this is not only indicated by its appearance and chemical constitution, but by the remains of water-courses or sloughs, that, although then perfectly dry, had evidently been once filled with water. Numerous fresh water shells, especially those of the genus *Planorbis*, common in fresh water lakes, are spread over large areas of the surface many miles from any trace of water, and nearer to the foot-hills of the mountains than any overflows from the lakes in the lowest part of this valley now extend.

In some of the lower parts of the valley, there are groves of cotton-wood trees that have attained their full size, but do not appear to flourish. They are found on the borders of some of the ditches or dry water-courses, and around shallow, basin-shaped depressions, that had evidently been once occupied by water, but which were then entirely dry. These trees were rapidly decaying and breaking down, and it appeared as if the conditions under which they had attained their growth had changed, and that they were then suffering for want of sufficient water at their roots.

It is probable that during unusually wet seasons this portion of the valley is overflowed; but I believe the facts warrant the conclusion that a gradual dessication of the whole valley is in progress.

Tulare Lakes.—The lower portion of the broad valley is occupied by a chain of shallow lakes, that are connected together by shallow sloughs or canals. These sheets of water are of considerable extent, but they cover only a small part of the valley. It appears that there are three principal lakes, called Tulare, Buena Vista, and Kern Lake. The Indian names are said to be *Tache*, *Clin-tache*, *Cholam*, and *To-lum-ne*. Tulare Lake is the largest, and is the most northern of the series. It is west of King's River and the Four Creeks, whose waters it receives. The banks of this lake and of the others are low and marshy, and in most places are covered with a dense growth of rank grass and tule.[1] This forms a wide green margin about a portion of the principal lake, and the growth is so luxuriant and the ground so soft that it is almost impossible to reach the water. The width of this belt of green tule is variable. I am informed by Lieutenant Williamson, who has visited the northern end of the lake, that in some places it is over three miles. The plant grows partly in the water, but only where it is shallow, and in

[1] Tu-le is the Mexican name of the great rush, *Scirpus lacustris*, of the lakes and swamps. It is used by the Indians to make mats, and also for forming *rafts*, with which they take heavy loads across the rivers. For this purpose it is gathered in quantities, and tied in thick bundles. Its buoyancy is due to the air contained in the cellular tissue.

this respect resembles the ordinary rushes and flags of the New England States. It is like our large bulrushes in its form, but grows to an enormous size, attaining a height of from 8 to 15 feet, and sometimes a diameter of three-quarters of an inch. This plant occupies the ground to the exclusion of other forms of vegetation ; there are no shrubs or trees to overshadow it, and it constitutes a remarkable feature of the vegetable physiognomy of California.

The rivers tributary to the lakes enter by numerous mouths ; they, in fact, form broad deltas, that are covered with vegetation. The character of the vegetation along the Four Creeks has been described ; it extends along the whole course of the stream and its sloughs, but it is probable that the trees which grow in such thick groves near the mountains become less numerous, and finally disappear in the lower and more marshy portions of the course of the river.

The supply of water to these lakes must be very great ; King's River and Posuncula River are large streams, and do not become exhausted in the dryest seasons. During the early part of the summer, or when the snows in the Sierra Nevada commence to melt rapidly, they convey enormous quantities of water, and the level of the lakes is raised. This constant variation in the quantity of water carried to the lakes, and the changes from the wet to the dry season, have the effect to keep the level of the water continually changing. This is one of the great peculiarities of the lakes, and the shallowness of their beds, and the low, shelving form of their shores, causes an unusual addition of water to become immediately evident by the wide-spread submergence of the surrounding country.

These inundations are most extensive in the rainy season. Plains that have been scorched and cracked by the long drought of summer are overflowed, and the sun-baked soil absorbs enormous quantities of water. The lakes become greatly increased in length and breadth, and cover portions of the plains that, a short time before, had all the characteristics of a desert. At these periods of high water, the lakes sometimes communicate with the San Joaquin River by a slough or channel at the northern extremity of the Tulare Lake. This slough is like a canal, and is very deep near the San Joaquin, but eight or ten miles from this river it divides up into numerous channels, which become intricate and ramified as they enter the lake. It is said that when the level of the river is greatly raised by freshets it overflows its banks, and the water passes to the lakes by this slough. At seasons of low water, all communication between the river and lake is prevented by a bar at the mouth of the slough. In the dry season this slough may be crossed without finding water ; and it has been customary to drive cattle across near the end of the lake.

When we were encamped at Fort Miller, (July, 1853,) a party of rangers, who had killed the notorious bandit, Joaquin, arrived, and had been obliged to swim the slough, and one of the prisoners was drowned.

We know but little of the country west of the Tulare Lake, between it and the mountains, or of the plains lying between this lake and the smaller lakes at the south. At the time I crossed over to the western portion of the valley, no water was found until I came within a few miles of one of the outlying ridges of the western range. Here progress was stopped by a narrow sheet of water, or a marsh, in which the water was warm, muddy, and slightly saline. It was extremely offensive to the taste, and the shores were soft and miry, and no vegetation, other than a few dried weeds, could be found. No current could be detected in this pool, but it is probable that it is a portion of the slough which connects the lakes together.

Thick masses of saline incrustations were found about the shores, at the roots of tufts of dried "bunch-grass," where evaporation had been most persistent and rapid. This incrustation is

found to consist of carbonate of soda, sulphate of soda, sulphates of lime and magnesia, in traces, and chloride of sodium or common salt. (See specimen No. 256 of the collection.)

The two lakes—Buena Vista and Kern—are at the southern extremity of the valley; they are visible from the ridges of the Tejon Pass and the Cañada de las Uvas. They are comparatively small in extent, but their area is not known. Their positions have been well determined by the Survey, and they are, for the first time, correctly laid down upon a map.[1]

There does not appear to be much vegetation about these small lakes; it is probable that they are liable to great changes of area, so great, that the conditions of moisture are not favorable to organic growth. Kern Lake was found, by barometrical observation, to be at an elevation of 398 feet above the sea.

Evidences of a former submergence of the Valley.—From the facts that have been stated in regard to this valley, it becomes evident that at a former period the lakes were more extensive; and that, in fact, the greater part of the valley was submerged by a broad lake.

The broad, alluvial tracts of clay soil along King's River and the Four Creeks, and the extensive plains of similar alluvial character, far from any water-courses, and above the reach of modern inundations, may be regarded as having a lacustrine origin. The limits of this alluvial formation may be considered as marking the former area or extension of the lake. I have taken the observations made at distant points, and from them drawn the limits of the alluvium on the Geological Map, and colored it to correspond with the alluvium of the delta of the Sacramento and San Joaquin.

All the facts indicate that this wide area was formerly covered with fresh water, and that it has been gradually drying up. Although there may have been extraordinary floods, at intervals, which caused the lakes to extend nearly to their ancient limits, the prevailing tendency has been to a complete dessication of the region.

It is not easy to give a definite and precise explanation of the cause of this gradual dessication. It is probable that it is partly due to a change of level, whereby the valley was drained. It is also probable that depositions of sediment by the San Joaquin, and other streams, have raised the level of that end of the valley near the San Joaquin, so as to shut off the communication with this river. It is very possible that the principal part of its water was formerly delivered to the lakes.

Rapidity of evaporation from the surface of the lakes.—Whatever cause may be assigned for the change in the condition of this valley, the rapidity of evaporation from the surface of the water in that region should not be overlooked in the attempt to solve the problem. The amount of water that is taken up by the winds in that valley is astonishing. We have seen that during the dry season the lakes have no outlet, and that they are constantly receiving great quantities of water from the rivers; the evaporation from their surfaces must then be equal to, if not greater than, the supply. The conditions under which these lakes are situated could scarcely be more favorable for this result. The strong winds that rush inland from the Pacific during the day, pass over the broad, heated plains, and the numerous ranges of the Coast Mountains, before they reach the valley. They thus part with the greater portion of their moisture before they pour in upon the Tulares. The shores of the lakes being low and shelving, and without trees, no resistance is offered to these hot and dry winds; they sweep over the surface and absorb the water with surprising rapidity. The rapidity of the evaporation is increased by the tem-

[1] See the General Map; also, the accompanying General Geological Map.

perature of the water, which is fully exposed in the shallow lakes to the rays of an unclouded sun, and becomes much heated.

The parching effect produced by these winds, and the evident rapidity of evaporation of any water exposed to their action, induced me to make an experiment to determine, if possible, the amount of water taken up each day. This experiment was made at the depot camp, on Ocoya Creek, in the following manner: A large sheet-iron pan, such as is used by the miners for "prospecting," and which corresponds very nearly in size and shape with an ordinary milk-pan, was placed upon a firm stand about two feet above the surface of the ground. This pan was nearly filled with water and a thermometer and small ivory scale were immersed in it. The whole was in a situation favorably exposed to the action of the winds, and was protected from the direct rays of the sun by a shed, covered with brush and leaves. The shade prevented the sun from unduly heating the water by acting on the bottom and sides of the pan. The amount of evaporation was noted from time to time by the height of the water on the scale. The results are given in the annexed table.

TABLE SHOWING THE AMOUNT OF DAILY EVAPORATION AT OCOYA CREEK, CALIFORNIA.

Date.	Time.	Ther. air.	Ther. water.	Quantity evaporated.	Daily evaporation.	Remarks—winds, &c.
1853.				*Inches.*		
August 26	Sunrise	65°	62°			
	12 m......					
	2 p. m....	100°	80°	$\frac{2}{16}$		
	6 p. m....	....	78°	$\frac{2}{16}$	$\frac{4}{16}$	Wind NW. and steady from 11 a. m. till sunset.
" 27	Sunrise	60°	58°			
	9 a. m....	85°	70°	$\frac{1}{16}$	....	Wind rising, and from the SW.
	12 m......	96°	78°			
	2 p. m....	100°	82°	$\frac{1}{16}$	....	Wind strong, and from NW.
	4 p. m....	100°	80°	$\frac{2}{16}$		
	5. 30 p. m..	96°	78°	$\frac{1}{16}$	$\frac{5}{16}$	
" 28	6 a. m....	60°	56°			
	12. 30......	95°	78°	$\frac{2}{16}$	....	Wind strong since 11 a. m.
	4. 30 p. m..	....	....	$\frac{1}{16}$		
	6 p. m....	....	....	$\frac{1}{16}$	$\frac{4}{16}$	Wind ceased at 6.
" 29	6 a. m....	52°	50°			
	12. 30 p. m..	86°	74°	$\frac{1}{16}$	....	Wind rising at 9 a. m.
	4 p. m....	90°	75°	$\frac{2}{16}$	$\frac{3}{16}$	

From this table it will be seen that the observations were continued for four days, and that the mean daily evaporation was *one-quarter of an inch*. This was shown not only by the sum of the daily or hourly results, but by the total loss in the four days as indicated on the scale at the close of the experiment. This result was below my anticipations, and yet when the depth of evaporation is multiplied by the superficial area, the quantity appears enormous. The rapidity of the evaporation was doubtless retarded by impurities in the water, which was taken from the creek, and soon deposited a slight sediment, and on the third day was covered with a thin film or pellicle, probably of light dust, which must have greatly protected the water from the action of the air.

It will be observed that the evaporation ceased at night. The temperature of the air was always rapidly reduced after sunset, but there was no dew. As these low, night temperatures did not influence the result, we may take the mean of the day temperatures both for the air and the water at the time of observation, subject to the slight error caused by the deficiency of observations on the 26th and 28th, and obtain approximately the temperature conditions of the air and water for that amount of evaporation. These results are, for the air 83°.9, for the water 71°.5; time, 46 hours. Height of barometer 29.30.

Although at the time of these experiments I regarded the air as exceedingly dry, I have since been forced to the conclusion that its condition was not the most favorable to great and rapid absorption of water. The crests of the ranges of the Coast Mountains are not greatly elevated in that region, being, probably, less than four thousand feet, and during the day they are much heated by the sun; they do not, therefore, cause the precipitation of all the moisture which the air brings with it from the sea, and its thorough desiccation is not accomplished. A great part of its moisture is necessarily retained, and a capacity for the absorption of more is given by the elevation of temperature which it suffers among the interior ranges and valleys of the coast, and finally upon the broad and heated plain. It is well to consider these conditions in connexion with the experimental results, and if the air is thus highly charged with moisture, the quantity taken up must be regarded as very large. At the rate of one-quarter of an inch a day, seven inches and a half in depth would be removed in thirty days, or seven feet, seven and a quarter inches in one year. According to Dr. G. Buist, the amount of evaporation from the surface of water at Aden, on the Indian Ocean, "is about eight feet for the year."[1] The basis of this statement is not given, but it is interesting to notice that the amount agrees with my experimental result.

If we regard the experimental result as a fair measure of the evaporation from the lakes, we may readily calculate the amount of water taken from them during a month or year. We have 36 cubic inches of water for the daily evaporation from one square foot of surface, and consequently 522929.5 cubic feet from every square mile. This equals 16210.8 tons, or 4,052,703 gallons—a quantity of which we can scarcely form an adequate conception, and yet it is for one day only. If we measure the amount of evaporation in depth, and assume that the quantity evaporated is equal during each month in the year, we have, as before observed, seven feet seven inches and one-quarter for the yearly evaporation. The conditions which I have detailed do not, however, exist throughout the year. In the rainy months the evaporation is much reduced, or perhaps it almost ceases. It is almost certain, however, that the experiment does not show the full amount of evaporation for the summer; it is undoubtedly much greater, and the results can only be regarded as approximate. They are, however, important, and derive greater interest from the fact that few experiments of the kind have been made, and because the climatic conditions of that region are so peculiar.[2]

Resemblance between the Tulare Valley and the Colorado Desert.—It will be seen, by comparing this description of the Tulare Valley with that given of the Colorado Desert, that the valleys resemble each other in their important characteristics. It is probable that their geological history is similar; but, although of the same age geologically, the changes in the Desert Valley have been most rapid, and its complete dessication has long since been accomplished. This difference

[1] Trans. Bombay Geographical Society, vol. ix, 1849–50, p. 39.

[2] The results of the experiment upon the amount of evaporation were communicated in a paper read before the National Institute, at Washington, March 4, 1856, and subsequently published in the American Journal of Science, May, 1856.

of their present condition is attributable to the configuration of the regions. East of the Tulare Valley we find a lofty chain of snowy ranges, which condense the moisture in the winds from the Pacific on their summits, and send numerous streams into the valley for its irrigation. If there was a similar high range east of the Desert, it is probable that sufficient water would be, in like manner, condensed on its summit, to form streams that would irrigate the Desert, as the Tulares are now watered by the streams from the Sierra Nevada.

GEOLOGICAL MAP
OF THE
TEJON PASS & CAÑADA DE LAS UVAS
AND THE VICINITY.
INCLUDING THE PASS OF
SAN FRANCISQUITO & WILLIAMSONS
PASS.

CHAPTER XV.

GEOLOGY OF THE TEJON PASS AND CAÑADA DE LAS UVAS—SECTION OF THE SIERRA NEVADA.

SIERRA NEVADA AT THE TEJON.—BOUNDARIES OF THE TEJON.—TEJON PASS AND CAÑADA DE LAS UVAS.—GEOLOGICAL MAP AND SECTIONS.—SECTION OF THE SIERRA NEVADA AT THE TEJON.—ROCKS OF THE WESTERN RIDGE.—PLANES OF STRUCTURE OR LAMINATION.—GRANITIC OUTCROPS IN THE PLAIN.—SECTION AT THE TEJON RAVINE.—WHITE LIMESTONE.—ROCKS AT THE ENTRANCE TO THE PASS.—DRIFT DEPOSITS.—OAK TREES.—ROCK AT THE SUMMIT AND BEYOND.—QUARTZ ROCK.—WHITE CRYSTALLINE LIMESTONE AND QUARTZ ROCK.—PROBABLE SEDIMENTARY ORIGIN.—PLICATIONS OR FOLDING OF THE STRATA.—PROBABLE CARBONIFEROUS AGE.—GENERAL TREND OF THE ROCKS.—TERTIARY AND POST TERTIARY DEPOSITS.—DRIFT OF THE VALLEY OF THE PASS.—SECTION AT THE CAÑADA DE LAS UVAS.—OBSERVATIONS ON THE SECTION; ITS DIRECTION.—SIMILARITY OF THE ROCKS TO THOSE OF THE TEJON.—WHITE CRYSTALLINE LIMESTONE IN RIDGES.—GRANITE NEAR CASTECA LAKE.—LIMESTONE WITH TRAP DYKES AND IRON ORE.—PROBABLE SYNCHRONISM OF THE LIMESTONE WITH THAT OF THE TEJON.—VOLCANIC ROCKS AND SANDSTONE.—RELATIONS OF THE VALLEY OF THE PASS TO THE BERNARDINO SIERRA AND THE SLOPE OF THE GREAT BASIN.

The Sierra Nevada at the southern part of the Tulare Valley ceases to be a range of snowy heights, and is broken into a series of ridges, not exceeding six or seven thousand feet in elevation. These ridges do not conform in their direction to that of the Sierra Nevada a short distance to the northward, or at the head waters of Posuncula River, neither do they exhibit any well defined parallelism among themselves, but extend in different directions, generally inclining southwesterly, turning more and more to the west as they succeed southward, until their direction becomes nearly transverse to the general direction of the Sierra Nevada, and they unite with the mountain ranges lying west of the Tulares; commonly known as the prolongation of the Coast Range or Coast Mountains. The angle which is thus formed by the intersection or unison of the Sierra with the Coast Mountains is not abrupt nor well defined; the ridges being arranged so that they form a great curve around the head of the Tulare Valley, and partly enclose the large space known as the Tejon. On the northeastern side of this plain-like area, a projecting ridge of granite forms a partial boundary on the north, and extending nearly parallel with the main ridge, it shuts off a portion of the Tejon from the broad plains of the Tulare Valley. The portion of the Tejon thus bounded is a nearly quadrangular space with mountains on three sides, it being open only towards the southwest. It was in this part of the Tejon that the Depot Camp was located.

The Tejon Pass extends from the eastern side of this part of the Tejon, by the valley of the Tejon Creek, over the crest of the Sierra to the Great Basin on the eastern side. Its general or average direction is N. 60° W., S. 60° E. The Cañada de las Uvas is about twenty miles further to the southwest, and may be said to turn the southern extremity of the Sierra Nevada.

The relative positions of these passes, and the direction of the mountains, may be seen by reference to the small Geological Map prepared to accompany this chapter. The topography is taken from the General Map of the Survey, and is on the same scale. The portion of the country represented includes the southern end of the Sierra Nevada, from Tah-ee-chay-pah Pass southwesterly to the Cañada de las Uvas; also, a portion of the Bernardino Sierra, from the Pass of San Amédio to Williamson's Pass. On the western side of the Sierra Nevada, the slope of the

Tejon, and the plain of the Tulares, are represented as far as Kern Lake; and on the eastern, the elevated plateau of the Great Basin to the Dry Lake.

The chapter is also accompanied by geological sections of the Sierra Nevada at the Tejon Pass, and at the Cañada de las Uvas; also, a partial section from the Tejon to Tah-ee-chay-pah Prairie. The profile lines of these sections are taken from the results of the Survey, the altitudes having been determined by the barometer and level and the distances measured by the chain.

The observations upon the rocks were connected as far as possible with the different barometrical stations. As the line of survey, however, followed the lowest parts of the pass and for a part of the distance along the bed of the brook, the examinations of the rocks were necessarily at a little distance from the line. The surveyed line was not in all cases transverse to the trend of the rocks, consequently it was not possible to represent them in their relative positions on the profile of the Survey; it being prepared from the observations along the crooked trail, and consequently representing a much greater width of rock formations than exists. The profile for the geological section has, therefore, been modified, and the principal points of observation have been referred to straight lines drawn, as nearly as possible, transverse to the predominant trends of the rocks. The line of section on the eastern side of the summit is nearly transverse to the trends, but on the western side, along Tejon Creek, it is slightly oblique; thus the rocks on that side are represented with a greater thickness or development than they really have.

In consequence, also, of this modification in the direction or length of the profile, the distances of the principal stations relatively to the Depot Camp do not correspond with those given on the railroad profile of the Survey. A scale of miles is placed on the section and will serve to give the distances with approximate correctness, but it cannot be used with accurate results in measuring the thickness of the beds of rocks differing in character, for in some cases, as has been stated, the trends are oblique to the line of the section, and in others it was impossible to draw the line of demarcation between one modification of the gneissose metamorphic rocks and another.

The section commences at the lowest point of the Tulare Valley, at Posuncula Lake, and extends westwardly in a straight line to the Depot Camp, at the Tejon; thence across the plain to the entrance of the Pass, and through it to the Great Basin and the bed of the Dry Lake—the lowest point in that vicinity. The regular descent and unbroken surface of the Tulare slope cannot fail to be noticed; and the difference of the altitude of its intersection with the granitic ridges of the Sierra, compared with the altitude of a similar point in the Great Basin on the other side, is well shown on the section. At station 11, the elevation of the upper edge of the slope is about 1,900 feet above tide; and on the Great Basin side, at station 212, the elevation of the slope is 3,700 feet. This shows a difference of 1,800 feet; but the difference becomes greater if, instead of taking the elevation of the Tulare slope at station 11, it is taken at the base of the outlying ridge of granite west of the Depot Camp.

The highest point of the section represents the lowest part of the divide, or ridge, of the Sierra that could be found in that vicinity. This is 5,300 feet above tide; but on either side the ridges rise from one to two thousand feet higher. An elevated point on the north was estimated to be about 7,000 feet high.

In each of the sections illustrating the chapter, the rocks or formations are represented as they appeared *above* the trail or surface. As in most cases the dip was nearly vertical, this representation is extended for a short distance above the line of observation, so that the char-

acter of the rocks could be made evident. The representation is thus confined between the line of profile and one drawn parallel with it, and a short distance above. This line is entirely arbitrary, and is used merely to limit the extent of the signs used to denote the character of the rocks. The elevation and general character of the outline of the ridges and summits is shown by the lines sketched in above the line of profile.

SECTION OF THE SIERRA NEVADA AT THE TEJON PASS.

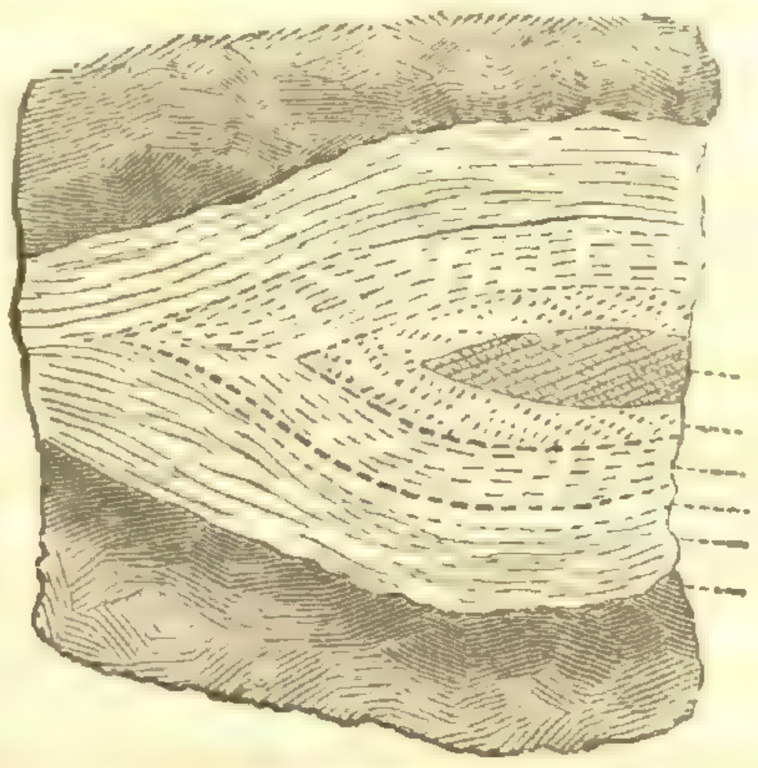
Granitic and metamorphic rocks.—The rocks now generally classed as *metamorphic* by geologists, and known as gneiss, mica slate, hornblende slate, and chlorite slate, are the predominating formations of the Sierra Nevada at the Tejon. They present various appearances, corresponding very nearly with those of rocks of the same name on the Atlantic slope of the continent; but they vary so greatly in their apparent composition, and in the relative quantities of the composing minerals, and they pass by such insensible gradations from one to the other, that no well-defined line of demarcation can be found between them. The transition from these rocks to compact granite and syenite is also gradual, and even these last named rocks present traces of lamination, or structure, which closely connect them with the others.

In the following descriptions of these rocks, the use of terms, or names, indicating the existence of separate formations, will therefore be avoided as much as possible, and, in general, the rocks will be described by specifying the predominant minerals and their state of aggregation. This absence of well-defined lines of separation between the different varieties of the rocks also prevents a representation of them by different colors on the map and sections. The attempt has, however, been made to indicate the variations in the rock, and the extent of lamination, by means of fine lines. These representations are accompanied by short notes on the lithological characters. In some cases where the names *mica slate, hornblende slate, chlorite slate,* &c., are appropriate, and will not lead to a misapprehension of the true structure of the rocks, they are retained. The rocks will be described in their order of succession from west to east—from the most western outcrop at the margin of the Tulare plains to the last exposure at the slope of the Great Basin on the east.

The following detailed description of the granitic rocks of the most western ridge will serve to give an idea of the general structure of the rocks in the main part of the chain, and to explain terms which will frequently be used in succeeding descriptions:

Although the rocks of this ridge may be called granite, or granitic, they are not compact and homogeneous, but consist in great part of hornblende, feldspar, and mica, arranged in long parallel lines, so as to give a slaty character to the mass. The hornblende and feldspar are found in long belts and in lenticular masses intercalated with mica, veins of feldspar, and seams of quartz. These lines, or belts of different mineral composition, are exceedingly numerous, and present frequent alternations with each other. There is not, however, any well-defined line of separation between them; the transition from one to the other being gradual, and almost imperceptible. Where the mica predominates, the surface decomposition appears to have been the most rapid, and the portions of rock containing the harder minerals are left standing in relief. A portion of the rock has a compact syenitic character, and, in addition to the minerals already mentioned, contains lines of epidote and garnets. Many lines of these minerals are often found in the width of a single inch; they extend for long distances in nearly parallel lines, and often have a local divergence or bulging, surrounding lenticular

masses, or concentric layers of the same or other minerals. A good illustration of this structure was carefully copied, and is represented of the natural size in the figure.

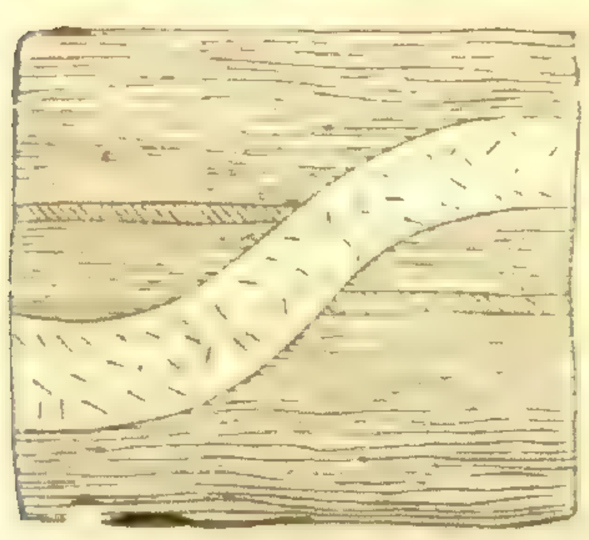


SEGREGATION IN GRANITE.

The central portions of the mass were of epidote of a light green color, without any distinct traces of crystallization. This was surrounded by a layer of garnet, intermingled with a small portion of quartz and feldspar; next a layer of hornblende and quartz in fine grains, the outer part being more quartzose; then a layer of the same minerals in a state of more perfect lamination; and, lastly, the same in a more coarsely crystalline condition, containing a portion of mica. This alternation of minerals in various conditions of arrangement is repeated indefinitely, and an instance of a much more complex character might have been selected—one in which a greater number of lines of minerals could have been represented.

These peculiarities of structure are similar to those seen in the granitic and metamorphic rocks of the Appalachians and in the azoic rocks of northern New York, where magnetic iron frequently forms the centre of the nodular masses. By the extension or drawing out of such lenticular aggregations the lines of minerals become nearly parallel, and numerous examples of this were observed. We must look for an explanation of these phenomena to the action of forces of crystallization, or polarity, when the rock was in a semi-fluid state; the stratiform condition which results should not be regarded as proof of a sedimentary origin of the rock. The rock under consideration is very probably a metamorphosed sediment, but the linear arrangement of the minerals is not regarded as a satisfactory evidence of it. The structure also appears to have taken place in the rock when it was so far fused as to obliterate the original planes of stratification, if any existed. I therefore avoid the use of the words *strata* or *stratification* in relation to these rocks, and designate the lines or layers of minerals as *planes of structure*, or of *lamination*. These planes, as developed in the granite ridge that has been described, have a direction or trend nearly north and south; there are, however, several local variations of 10° to 20° from this direction. Their dip is westward, at an angle of 75°, which was found to vary at different points of observation.

The rocks are cut and traversed by several granite and quartz veins running in various directions transverse to the planes of structure. One narrow vein, composed principally of feldspar, was observed to conform to the direction of the lamination for a part of its course, and then to pass diagonally for a short distance, cutting across the planes of structure, and "faulting" a narrow seam of quartz as if it had been forcibly inrupted. The walls of this vein consist of feldspar, mica, and hornblende; the junction between them and the vein appears to be perfect, and does not present any indication of fracture.



In one of the small cañons of the ridge, a vein of ferruginous quartz about two feet thick is

exposed. It is much stained and rusted by the decomposition of iron pyrites, which probably exists in an unaltered state a few feet below the surface.

Between the western ridge just described and the main ridge of the Sierra there are several granitic outcrops of small extent rising at intervals from the plain, showing that it is underlaid at only a slight depth by an uneven surface of granite. All the minor inequalities of the surface have been filled, and the rocks buried from sight, by the drift deposits of sand, gravel, and boulders that form the slope. These isolated outcrops conform in their general structure, trend, and dip to the ridge already described. A more compact rock, a gray granite, with the planes of structure obscurely developed, is also found. The outcrops of the rocks bordering the valley on the north are much obscured by a covering of drift, or similar accumulations; but wherever they were exposed to view a laminated structure was visible. They are nearly all gneissose, and less hard than the dense hornblendic rock of a part of the western ridge.

Section at the Tejon Ravine.—A good natural section, about three miles in length, is formed by the creek that flows from Tah-ee-chay-pah prairie to the Tejon. Its general direction is east and west, which is nearly at right angles to the trends of the structural planes of the granitic rocks. The general character of the rock may be understood by referring to the section, (Section 6, Sheet IV.) The fine lines are intended to represent the lamination and structural characters. It is, of course, impossible to make a perfect miniature representation of the rock, or to show the numerous plications and curves that exist. Hundreds of lines are contained in a single foot of rock; while in the section over five thousand feet are represented in the space of a single inch.

The first part of the exposed rock at the entrance to the ravine contains a large proportion of mica, and numerous feldspathic veins; in some places it is highly laminated, and much flexed and contorted, presenting various dips at different distances below the summit. The foldings and contortions are well developed on a small scale, and at the same time are subordinate parts of more extended curves and plications. A short distance beyond station 52, and on the south side of the ravine, there are indications of an outcrop of white crystalline limestone. Its junction with the granitic rocks is covered by earth, so that its extent and position could not be exactly determined; but that it exists in considerable quantities is shown by the loose masses that roll to the foot of the hill, and abound in the small cañons and ravines at its base. This limestone will be found valuable for making caustic lime for buildings on the Military Reserve, and other settlements in the vicinity.

Beyond this, and on the north side of the ravine, the granitic rock becomes more compact and contains hornblende, but retains its laminated structure. About station 40, mica is abundant, and the rock is gneissose and much contorted. Towards the summit, the rocks grow more compact and less highly laminated; they contain less mica and are more like ordinary granite. Wherever this compact rock is fully exposed to the action of the weather it presents rounded outlines, instead of the ragged and angular surfaces that characterize the more slaty and laminated portions.

The minerals which form this granite are feldspar, quartz, hornblende, and mica; the two latter appearing to be the varying constituents, and either found together in like proportions, or one predominating over the other without producing any great change in the appearance of the rock. It resembles syenite, and has a very even texture, and light, gray color. There is, however, an abundant distribution throughout the mass of isolated patches of a darker color than the surrounding portions; and these masses have a lenticular or elongated form, and preserve a general parallelism of direction, corresponding with that of the planes of structure in

the adjoining rocks. These lens-shaped and elongated masses appear to differ from the enclosing rock merely by the greater amount of either hornblende or mica that they contain. They are, doubtless, the result of the action of the same forces that produced a more distinct and laminated structure in other parts of the same range. They are, also, harder, and offer greater resistance to the disintegrating action of the atmosphere; they, consequently, stand out in relief from surfaces that have been exposed to weathering. This is distinctly shown on the great erratic masses that lie on the surface near the entrance to the Tejon.

Some portions of the compact rock disintegrate rapidly, cracking up into soft and friable masses, that crumble readily when struck by the hammer, and fall into grains about the size of peas. This is more especially the case with the granite in which the crystals of mica and feldspar predominate, and appears to be a separation between the constituent minerals rather than a division into their particles.

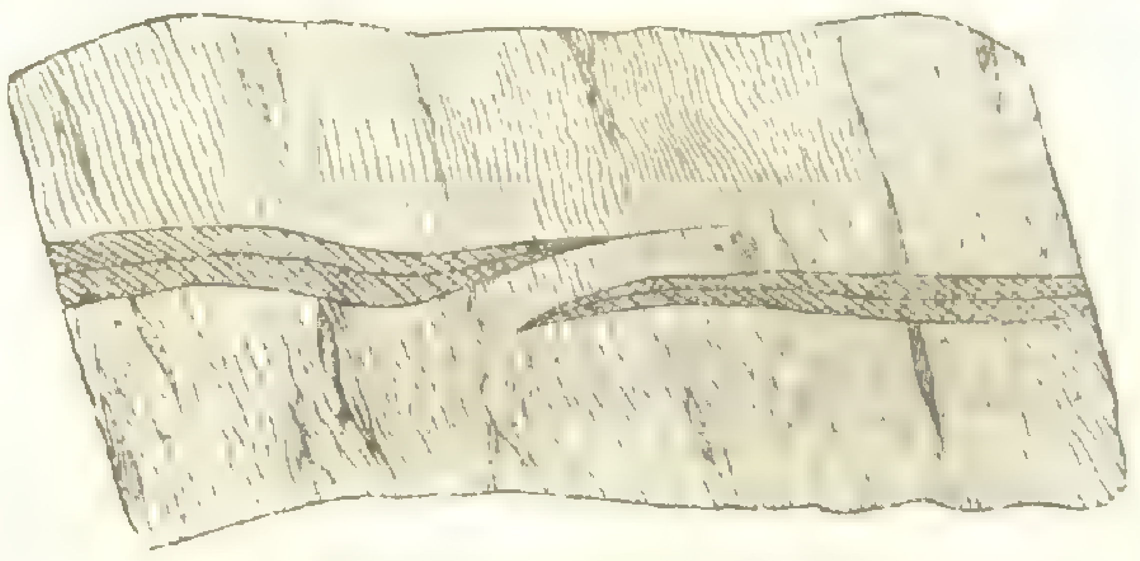
Tejon Pass.—The Tejon Pass is divided from the Tejon ravine by one ridge only, and the granitic exposures in each have a general similarity. The Tejon Creek, which rises at the summit of the Sierra, flows through the Pass at the base of the ridges on the south side. It here makes good exposures of the rock, while on its left bank, or north side, it is bounded b high banks of drift accumulations, in which it appears to have excavated its channel. This drift occupies a large area in the valley of the Pass, and is deeply furrowed and cut into ravines by the side streams that have descended from the high ridge on the north. As this drift completely obscured the rocks on the north side, they were not examined, and the following descriptions, as far as the summit, apply to the exposures on the south side of the Pass only.

The trend of the planes of structure in the granite, at the point of rocks at the entrance to the Pass, (station 11, see Section 5,) is N. 48° W. by the needle, and their dip is nearly vertical. The rock is laminated and slaty, but quite hard, and the surface is rough and angular. Directly over the summit of this low projecting point the rocks are well exposed, and a narrow belt of a very finely laminated syenitic granite appears, which contains a large amount of small garnets, epidote, and granular quartz. The rock also contains black hornblende in such quantity as to give it a dark shade, which distinguishes it from that adjoining it on each side. All these minerals are arranged in numerous narrow seams, forming an exceedingly hard and compact rock, cleaving most readily in the direction of the structural planes, which are sufficiently numerous and regular to give a slaty appearance to the mass.

The mass also breaks up readily in two directions nearly transverse to the planes of structure, producing triangular and rhombic masses, similar in their forms, and in the value of their angles. These were measured as accurately as possible, and found to be 110° and 70°. The trend of this rock is N. 25° W., (magnetic;) its dip nearly vertical, inclining slightly eastward. Although the outcrop has a width of only twenty feet, I have deemed its interesting structure worthy of a minute description, especially as it is intercalated with rocks of a more micaceous and granular structure.

A few rods further to the east the structural planes of the granite have a well-defined dip to the northeast of 70°, and the rock is traversed by nearly horizontal veins of feldspar, composed of an intermixture of beautiful white and reddish feldspar, with a thin central seam of epidote, and an occasional grain or crystal of quartz, or black mica. This vein was traced along a vertical wall of granite for about one hundred and fifty feet. At several points it was disjointed, the ends being thinned down to a mere line, and overlapping each other. They were separated

by several inches of the laminated rock, as is represented in the figure, but no disturbance in the structural planes could be detected. These are probably segregations, and not intruded.



SEGREGATED FELDSPATIC VEIN.

Beyond this, a short distance, the structural planes are not so well developed, and the rock is syenitic, and of a compact and uniform texture, and resists decomposition well. Its trend is N. 40° W. In one of the ravines, where a nearly vertical wall of rock is exposed, I observed a smooth and undulating surface, similar to that frequently exhibited at the junction of dykes of trap with granite, and on the walls of mineral viens, appearing to be the result of motion and pressure when the rocks were in a plastic state, and very different from "slickensides" or the grooving and polishing produced on the walls of veins by the sliding of the rocks after their consolidation. It is possible that, in this instance, the granite formed the wall of a feldspathic vein, now entirely removed by disintegration.

At station 58, the outcropping granite is gray and compact; and the lenticular masses of hornblende and mica, similar to those already described as occurring in Tejon ravine, are well developed. Their direction, or trend, is N. 72° W.; dip north estimated at 50°. The direction was observed at several places, with the same result as above. This compact granite continues to the summit-level with but little variation. The greater part of its surface in the valley of the Pass is buried beneath a great heap of erratic blocks and drift-gravel confusedly stratified. At the summit, station 140, there are several outcrops of the granite of limited extent; it becomes more structural, and contains a large amount of hornblende and mica. The mica is olive-green, and is in small plates and obscure crystals.

The soil which results from the disintegration of the granite and the associate rocks appears to be peculiarly favorable to the growth of oaks, of which there are numerous species.[1] *Quercus Hindsii*, or *macradenia*, is found growing on the rocky ridges and on the drift formation throughout the Pass, and is most abundant towards the summit, but attains its greatest size in the valley, in situations sheltered from the prevailing winds. Pines also grow luxuriantly in the cañons of some of the highest ridges. From the summit to the Great Basin the rocks are covered by a deep granitic soil, and the surface is generally rounded, and in some places supports groves of oaks. This, however, is the character along the wagon trail; the Survey followed the course of a ravine, or creek, along which the rocks were favorably exposed. Even at the summit it was difficult to find good exposures of the rock, there was so much soil and grass. At station 149, a short distance below the summit, there is an outcrop of laminated, but compact, hornblendic granite, cleaving into rhombic masses; this is succeeded by granular granite, with a distinct structural character. Below this, near station 151, are beds composed almost entirely of hornblende crystals, coarsely aggregated, the color varying from black to dark and light-green. In

[1] The following are some of the species of which leaves were obtained and drawings made. They were determined by Dr. Torrey: *Quercus macradenia*; *Q. agrifolia*; *Q. agrifolia*, (a dwarf species); *Q Douglasii*; *Q. crassipocula*, (n. s.) Torrey; *Q. Parryana*, (n. s.) Torrey; *Q. Garryana*. *Quercus crassipocula* is a most interesting species. The leaves are thick and glossy, and more like those of the orange tree or lemon than the ordinary oak. The acorns are enormous, and very beautiful.

portions of the rock the crystallization of the hornblende is fibrous and acicular, resembling varieties of asbestiform actinolite. This rock, for a thickness of twenty feet, is entirely free from either quartz or feldspar; and, like all aggregations of fibrous hornblende, is very tough and difficult to break.

From this point to station 172 the rock is a syenitic granite, showing a structural arrangement of the minerals, and changing by insensible gradations to varying conditions of lamination. Hornblendic, micaceous, and chloritic slates, with imbedded quartz, succeed.

At station 176 there is an exposure of a peculiar quartzose rock, forming a bed, in which the quartz is disposed in nearly vertical planes, interleaved with delicate films of brilliant, silvery mica, which fold around the grains of quartz on the flat surfaces, and disguise the true character of the rock, which can only be seen in a cross fracture.

East of this laminated quartz rock there is a succession of chlorite rocks, with a slaty structure, and much stained by oxide of iron. At 183, a series of outcrops of quartz rock and white crystalline limestone commences. The beds are of various thicknesses, dipping to the east, or southeast. The quartz rock, which is the first of the series, and adjoins the ferruginous chloritic rock, is compact, amorphous, or sub-granular, and is without the usual vitreous lustre of quartz. Portions of the rock are deeply stained with oxide of iron, probably from the infiltration of ferruginous water derived from the decomposition of pyrites. There are also indications of structure or stratification in the mass. Its general appearance and condition is entirely different from that of the granitic series that has been described, and it resembles a sandstone in a condition of semi-metamorphism. The white limestone is in immediate contact with this quartz rock. Its texture varies from the ordinary coarsely crystalline varieties to a compact sacharoidal marble. Scales of graphite are disseminated in some portions, but no other minerals commonly occurring in such limestone were found at this outcrop. The width of this bed was about 200 feet, and it was succeeded by another similar one, separation between them being effected by a thin bed of quartz rock, conformable with the limestone beds, and similar to that last described.

The relations of the series can be seen on the section, or in the annexed section from the notebook, in which, however, the relative thicknesses are not correctly represented.

LOCAL SECTION NEAR STATION 183.

a chloritic slates; *b b* quartz rock; *c c c* white limestone; *d* syenitic granite.

A belt of syenitic granite is interposed between these limestones and another series of beds of limestone, alternating with quartz rock, coming to the surface near station 191. These are again succeeded by granite and hornblende slate of a compact texture, which, near one of the limestone beds, appears like a trap rock, breaking up into hard angular fragments, but still showing a distinct slaty structure. The section continues to present a succession of dark and light-colored syenites, passing into granite, in which the structural planes are developed in varying degrees to near station 206. At this point there is believed to be another outcrop of limestone; one is recorded in section in the notes, but it is unaccompanied by any description except the mention of the presence of hornblendic slates on each side. Whether this outcrop is at 206 or further east is uncertain. Its inclination, however, is towards the east.

At a point near 212, quartz rock again makes its appearance in a bed about one hundred feet thick; then follows a fine-grained syenite two hundred feet thick; and a second bed of quartz and one of limestone, (at 212,) in which there are numerous imperfectly formed crystals of a brown garnet.

This is the last outcrop of limestone in the Pass, and is succeeded, five hundred feet eastward, by a fine mica and hornblende slate, with a trend N. 37° E., dip S. E. about 45°. This rock is remarkably homogeneous, and its trend and dip is unusually distinct. It has planes of cleavage other than those in the direction of the beds, giving to the broken masses a sharp, angular outline, which, with the dark color, makes them resemble a trap or basaltic rock.

This series of beds of granite, quartz rock, limestone, and hornblendic rock presents a slightly different appearance when examined at the outcrops along the wagon trail about three-quarters of a mile further north. There, the last described syenitic rock is more highly crystalline, and contains transverse veins of white limestone and quartz several inches in width. These rocks are the last that are exposed in the natural section, and hardly rise above the surface of the broad slope of the Great Basin, which is composed of sedimentary accumulations of modern age.

We have thus considered in succession all the outcrops of the rocks from the Tulare Plains to the summit of the mountains, and then downwards along the course of a creek on the east slope to the Great Basin.

It is evident that the rocks east of the summit are chiefly metamorphosed sedimentary formations, and it is probable that a great part of those on the western flank are also metamorphic. The predominance of the rocks, with the composing minerals arranged in parallel planes, is one of the most striking features of the section; and west of the summit it becomes difficult, if not impossible, to distinguish between the metamorphic rocks and those which are decidedly eruptive in their character. If the structural condition of the rock was regarded as conclusive evidence of its metamorphic character, we would be obliged to consider the whole series as metamorphosed. There is, however, little reason to doubt that the gray and compact granite, with its included lenticular masses of minerals, is eruptive. The beds of white limestone, with the adjoining beds of quartz rock, are exceedingly interesting. The limestone varies from a coarsely crystalline structure to a fine-grained, granular or sacharoidal marble. It is very white, and some of the beds contain disseminated crystals of graphite. The metamorphism is so complete that if the rock originally contained fossils, they are now completely destroyed. A part of the rock very closely resembles the coarsely crystalline white limestone of Sussex county, New Jersey.

The quartz rock may be regarded as metamorphosed beds of sandstone. The color is light buff, or yellowish, and not unlike that of the Potsdam sandstone along Lake Champlain. Several of the specimens exhibit a sub-granular structure, and prove to be calcareous.—(See No. 4, Catalogue and descriptions.) The recurrence of similar beds at regular intervals along the section leaves little doubt that they were formerly continuous, and that they have been uplifted and thrown into flexures, or plicated. This is also shown by the dips or inclinations of the beds, those nearest the summit being nearly vertical, while those lower down the slope incline at a considerable angle from the vertical. The flexure has possibly taken place as indicated upon the section by a dotted line. If such a plication exists, the upper parts of the curves have been removed by denudations. This view of the relations of the beds is presented with some hesitation, as the probable plication was not recognized in the field, and only became

apparent when the section was constructed. There is also some doubt about the position of the outcrop of limestone between stations 191 and 212. It was not possible, in a hurried examination of such an extended section, to give that attention to measurements and other observations upon the rocks which are essential to the truthful representation of plications.

It is worthy of remark, that here, as in the Appalachians, the most abrupt flexures, as indicated by the dip of the strata, are turned towards the ocean. The dips also indicate that the lateral force or wave producing the folding or undulation was from that direction, or from west to east.

In this section of the Sierra Nevada we do not find great masses of clay-slate or roofing slates, similar to those of the western slope of the Sierra in the latitude of San Francisco. Neither are the talcose or magnesian slates represented, unless the chloritic slates be regarded as their equivalents. The entire absence of all erupted dykes of porphyry, or even of ordinary trap or greenstone, so far as observed, is also remarkable. There are no indications in connexion with the limestone and quartz rock which throw light upon their age. Whether they are Silurian, Devonian, or Carboniferous is yet to be determined. There is some reason to regard them as Carboniferous, for these are the nearest known formations of limestone and sandstone which are recognizable by fossils. The carboniferous limestone has been recognized by Mr. Marcou as far west as the head-waters of the Ha-wil-ha-mook, or Bill Williams' fork of the Colorado, in longitude 113°, or about 350 miles east of these outcrops, and on the same parallel of latitude. It is probable that the bed of limestone on the western side of the pass is similar in its lithological characters and age to the outcrops on the east, but its exact relations to the adjoining rocks were not determined.

From a consideration and comparison of the different observations, keeping in mind at the same time the locality and the peculiar local conditions, I have been induced to regard the prevailing trend of the rocks of the main ridge between stations 125 and 212 as N. 20° to 30° E. One great reason for this conclusion is found in the general course of the crest of the ridge, which according to the results of the Survey has at that point a northeasterly trend, and it is believed to conform in a great measure with the trend of the composing rocks.

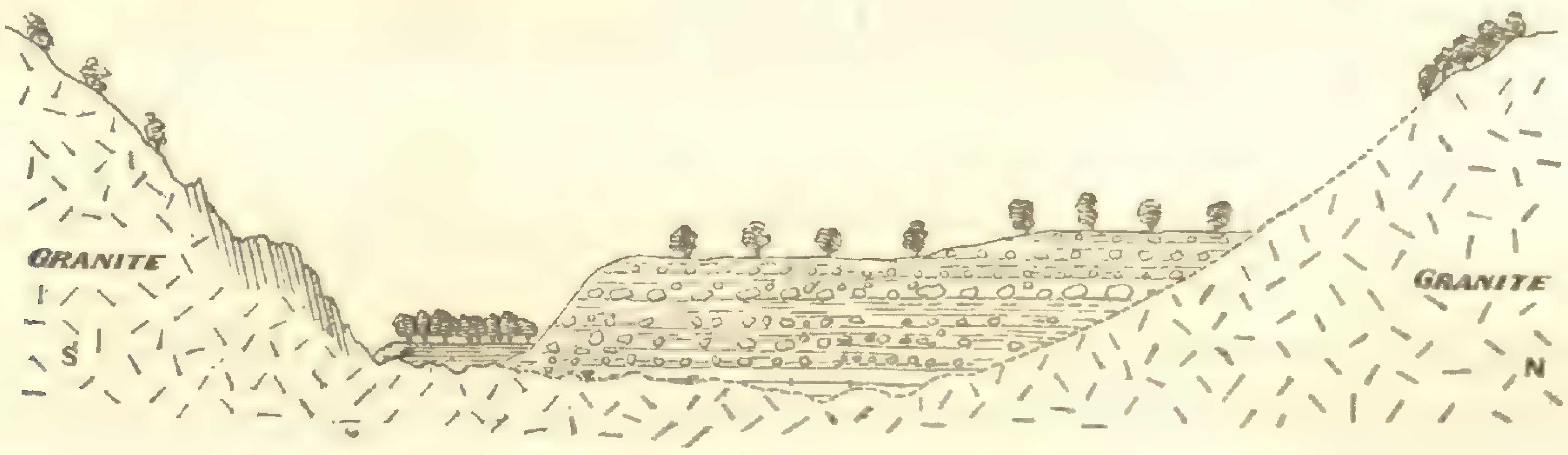
Trend of the granite of the Pass.—Observations upon the trend of the granite were made as frequently as possible, and whenever a suitable exposure of the rock was found. In the rough cañons and steep slopes of the ridges it was not always possible to catch an extended view of the outcropping edges of the rocks, and the trends as observed do not in all cases indicate their prevailing or predominant direction. The trends that were observed on the western side of the ridge were taken on the south side of the creek, and were all west of north, ranging from 5° to 40°, and one of 72°, but this is believed to be more westerly in its direction than is common, and, possibly, is erroneous. On the eastern side of the crest of the ridge, the trends, with some exceptions, were east of north, and were generally regular and well defined. The following are some that were noted—a correction of 14° 30′ having been applied for variation:

Station.	Trend.	Station.	Trend.
176	N. 14° 30′ E.	203	N. 30° W.
183	N. and S.	211	N. 30° 35′ E.
191	N. 15° E.	212	N. 39° 30′ E.
202	N. 15° W.		

Tertiary and Post-tertiary deposits.—The white and chalk-like banks or cliffs, which were observed in approaching the Tejon Depot Camp from the northward, are probably of the same age and lithological characters as the Miocene formation at Ocoya Creek. These hills flank the most western ridge of the granitic rocks, and slope down gradually to the level of the Tulares. They were not seen in section, and no observations upon their lithological characters can be presented. They are represented on the section. It is probable, however, that a continuation of these deposits underlies the whole of the detrital materials of the slope, and the alluvial and lacustrine clay of the Tulares; and finally reappears on the opposite side of the valley to form the foot-hills of the Coast Mountains.

The mountains north of the Depot Camp are more or less covered, up to an elevation of 1,000 to 2,000 feet, with sedimentary materials, which, in all probability, are Tertiary, overlaid by more recent deposits of drift or detritus. The surface is covered with transported fragments and boulders of various rocks, most of them porphyritic and not in place in the vicinity. One boulder over five feet in diameter was observed. The washing away of a large part of these deposits, and the erosion of ravines by running water during rains, has supplied a large quantity of loose earth and sand to be spread out over the adjoining slopes of the Tejon and Tulares.

The Tertiary deposits do not appear to extend as far east as the entrance to Tejon Ravine or Tejon Pass. In the Pass, however, there is an extensive accumulation of sedimentary materials of comparatively modern age. They are probably wholly formed of drift, or the rounded and water-worn debris of the adjoining mountains. This deposit occupies the bottom of the valley of the Pass nearly to the summit, and, as has been already stated, the creek has cut its channel upon the south side along the junction of the deposit with the granite. In travelling through the Pass, therefore, the granitic rocks are found on one side and rounded hills or steep banks of this drift deposit on the other. The many small tributaries to Tejon Creek, from the high ravines in the mountain on the north side, cut directly across the accumulation and form good sections, but they are generally so much overgrown with grass, and obscured by soil, that the lithological characters can hardly be determined. These sections show, however, that the deposit is at least over 100 feet thick; and it probably is in some places over 500 feet, and may be underlaid by Tertiary strata. The general form of the valley of the Pass, and the relative positions of the drift, are shown in the annexed section from north to south, a few miles beyond the entrance.



SECTION ACROSS THE VALLEY OF TEJON CREEK.

The materials composing this deposit are chiefly earth, sand, and gravel; and a large proportion of coarse drift of boulders and cobble stones, from six inches to four feet in diameter; masses of the latter size being rare. These are rudely stratified, as may be seen in some of the banks. The surface is generally undulating, and shaded by groves of oak. The transverse

valleys, or ravines, formed in this deposit by the little streams entering from the north, are, in several instances, terraced on both sides. Between stations sixty-two and one hundred and six, a ravine is very distinctly terraced, and is rendered more interesting by a deposit of rounded and angular masses of rock, from one to two feet or more in diameter, on each bank just at the margin of the terrace. These rocks are so thickly spread that the soil is invisible in some places, and in others, they are within stepping distance of each other. In width, this belt or margin of erratics is not over thirty or forty feet, and is generally more narrow. It is singular that they are found at the margins of the terraces only. It is possible that they are of glacial origin, but may have been washed out of the banks by the stream, when of greater volume than now, and accumulated along its bed, to be afterwards cut through by a more narrow and a deeper channel, and thus left, in part, on each side. Under this supposition, that the stream, producing the erosion, has gradually been diminishing in volume, the terraced form may be explained without resorting to the hypothesis of a sudden uplift of the region.

Local deposits of large blocks of granite are found at several places on the plain-like surface of the Tejon, between the site of the Depot Camp and the entrance to the Pass. This granite corresponds, lithologically, with the granite found in the Pass and in the upper portions of Tejon Ravine. The blocks have evidently been transported from the valley of the Pass or the ravine. They do not border the bed of any stream, but extend in long lines on the surface. Similar accumulations are, however, found along the course of the creek, after it flows from the ravine of the Pass. If the other accumulations were originally deposited along a creek, all traces of its bed are removed. Some of the blocks along the creek are over fifteen feet in diameter, and it seems hardly possible that they could have been rolled forward from their source even by a great flood. It is possible that they were transported by glaciers at some remote period when the climate may have been favorable for the formation of such bodies of ice.

The granitic and metamorphic rocks on the Great Basin side of the mountains pass beneath nearly horizontal strata, which are probably Tertiary. These strata are overlaid by a thick accumulation of more recently deposited materials—the wash and detritus from the ridges. It could not be determined whether the edges of the strata, which were obscurely exposed in the sides of the valley, were, in reality, very different from, or older than, the materials of the slope. They are, however, believed to be of the age of the Tertiary, and to extend beneath the superficial deposits of the Basin in the same manner as on the west side. Similar strata pass below the surface deposits of the Tulare plains. The probability that they are Tertiary is increased by the occurrence of sandstones believed to be of that period on the corresponding slope of the Cañada de las Uvas twenty miles further south.

SECTION AT THE CAÑADA DE LAS UVAS.

By referring to the Geological Map, it will be seen that the Pass, called the Cañada de las Uvas, is situated about twenty miles southwest of the Tejon Pass, and leads from the southern end of the Tulare Valley to the Great Basin. It may be said to turn the southern extremity of the Sierra Nevada, although the mountains are of equal altitude beyond. The break in the mountains is much greater than at the Tejon Pass, and the narrow cañon, or the rocky portion of the valley of the Pass is much shorter, and is near to the entrance from the Tejon or Tulare slope. Beyond this, the Pass is a succession of open, elevated valleys between ridges. This configuration of the Pass is not so favorable to observations on the granitic rocks, and they were

not as well exposed as in the ravines of the Tejon Pass. The whole width of the granitic exposure, by direct section across the strike of the planes of structure, is less than seven miles, but, including a second ridge, the point of which is skirted, it is about ten. The formations bounding the Pass for the remaining distance are Tertiary sandstones and accumulations of drift, with occasional outcrops of intrusive rocks.

The geological section of the Cañada, Section 7, Sheet IV, is constructed like that of the Tejon Pass, although on a different scale. It is intended to exhibit, as nearly as was ascertained, the structure or lamination of the rocks as they are exposed along the sides of the Cañada. As the prevailing trend of the planes of structure is east and west, the observations are referred to a straight line running north and south, so that the relative positions of the different parts of the rocks might be exhibited. Only that part of the section included between stations 1 and 40 are referred to this line. The portion showing the Tulare slope is along a line connecting station 1 with Kern Lake. The remainder of the section, from 40 to 74, is along the line of the trail, (east and west, see map,) and it is parallel with the prevailing trend of the formations. It is given merely to show the average elevation of that part of the Basin, and to indicate the character of the hills bounding the trail.

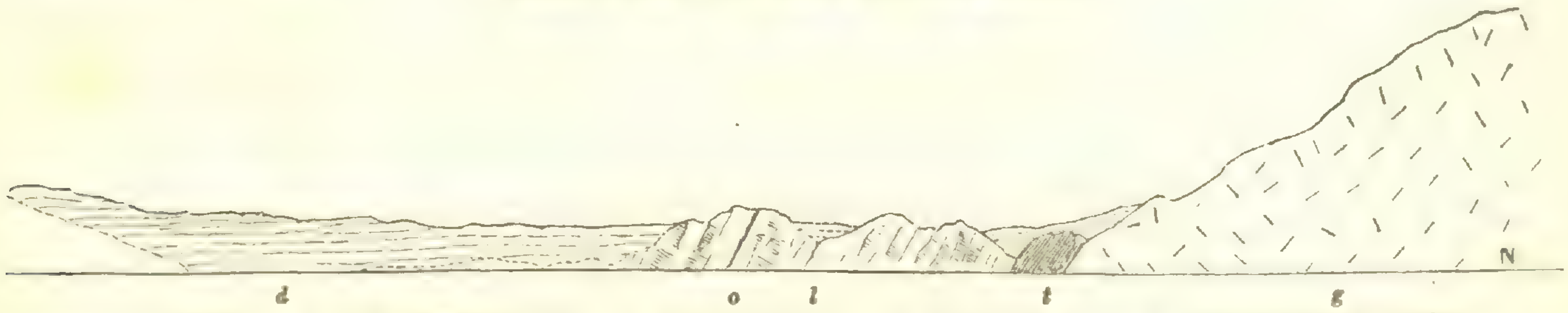
The first four miles of the pass is a narrow gorge, averaging less than one-quarter of a mile in width; it is in this portion that the principal exposures of the rocks occur. These rocks have a general similarity to those of the western slope of the Tejon, being generally hard and compact, although highly structural or laminated. Mica, however, appears to occur in greater abundance, and a part of the rock is unlike any observed in the section at the Tejon. That portion of the rock near the entrance from the Tulare slope is without hornblende, which appears to be entirely replaced by mica, in crystals about one-quarter of an inch broad. This mica is also disposed in narrow veins, traversing the rock, and looking, on the exposed edges, like black hornblende.

About two miles from the entrance the rock is highly laminated and less dense, and might be called a coarse mica-slate. Several of the specimens were very dark colored, and appeared to be imbued with plumbago. Half a mile beyond, the rock is more compact and like ordinary granite, and contains a considerable portion of white, silvery mica. Garnets were also observed. Beyond this, and nearly three miles from the entrance, the rock becomes more laminated and gneissoidal, and is succeeded beyond by more compact rock. This contains hornblende, and is thus syenitic, but is highly laminated or structural, and is traversed by quartz veins. About four miles from the entrance the rock becomes like the gray granite of the Tejon Pass and Tejon ravine, and contains similar lenticular aggregations of mica and hornblende. Here the valley of the Pass becomes more open, and the rocks are not favorably exposed for observation. The camp was located in this part of the valley in a grove of oak trees. Beyond it, and between stations 3 and 6, outcrops of white crystalline limestone occur, and trend obliquely across the valley, or nearly east and west. Nearly opposite station 15, at the end of the ridges where the valley opens towards the southwest, limestone again appears in several outcrops, apparently parallel with those first observed. The intermediate space is occupied by granitic or metamorphic rocks, but they are much hid, and indeed almost entirely covered, by a thick deposit of drift or Tertiary strata. The ridges terminate at this point, and are separated from those beyond by a narrow valley, and the small lake or pond called Casteca Lake, which, when dry, is white with salt left by the evaporation.

The granitic ridge which bounds this lake on the south is so much covered with soil and

drift, that the character of the rock is obscured, and a rounded and smooth outline is given to it. It forms a projecting point, around which the valley of the Pass bends, as will be seen on the map. The granitic character of the underlying rock is shown by several limited outcrops along the base of the ridge. At a point on the southern side, the rock appears to be composed of a simple mixture of quartz and feldspar, or albite, in fine grains, without mica. The mass much resembles some compact or metamorphic sandstones; it appears to decompose rapidly, crumbling to a white powder, which mingles with the debris of the overlying sediments. A short distance further west, and near the summit, but at the southern foot of this granitic ridge, (between 38 and 40 on the section,) we find a third series of narrow ridges of white limestone. They are accompanied by trappean dykes, with a nearly east and west trend. These give rise to a series of small, local valleys, parallel with the outcrops. A vein of iron-ore is intercalated in one of these limestone ridges.

SECTION NORTH AND SOUTH NEAR THE SUMMIT.



g. Granitic. *t*. Trap, or igneous rock. *l*. White limestone. *o*. Bed of iron ore. *d*. Drift deposits and Tertiary.

These outcrops and the dykes of trap, with the exposed surface of the adjoining granite, all trend nearly east and west, and thus are transverse to the line of the section. They are, therefore, represented upon it near station 38, or at the extreme southern part of the ridge, this being the point at which they would appear if prolonged in their line of trend. It is probable that another series of beds of limestone occurs on the north or opposite side of the ridge fronting on Casteca Lake. If so, there would be scarcely a doubt of the identity of these formations, in respect to age and metamorphism, with the limestones of the eastern slope of the mountains at the Tejon Pass. The three outcrops described, trending parallel with each other, and separated by granitic or metamorphic rocks, taken in connexion with the similarity of the adjoining granite to that of the Tejon, are, however, sufficient to justify the conclusion, that the formations are synchronous and similarly plicated. They are, in all probability, continuous along the eastern slope of the mountains, from one pass to the other.

The intrusive rocks which appear in connexion with the outcrops of limestone on the south side, or Great Basin slope of the ridge, are continuous towards the east on the north side of the valley of the Pass, among the sandstone formations; being best defined between stations 40 and 48, near the little ponds or lagoons.—(See 40 on the Section.) These dykes are of a dark color, very compact, and slightly porphyritic. Some peculiar rocks were observed in connexion with them, which appear to be the granite in a metamorphic condition. . It appeared to have been fused, so as to produce an intimate mixture of the minerals, and to have cooled without taking a crystalline structure.

This part of the Pass may be considered as the boundary or foot of the Sierra on the side of the Basin; the remaining extension of the valley, until it finally opens out upon the broad slope of the Great Basin, (see Geological Map,) may be regarded as a hollow, or valley of denudation, in the sandstones and hills of drift that form the upper and higher parts of the great slope. The hills on each side are low; but the strata of the sediments are not horizontal, having been uplifted by the intrusion of the volcanic rocks already mentioned, and by an addi-

tional series of ridges coming to the surface opposite station 74, at the extreme eastern end of the Pass.

This volcanic rock presents various shades of red and dark-green, and some portions of the dykes are distinctly laminated. Other parts are vesicular, and contain small masses of chalcedony, often forming only a thin lining on the border of the cavity; the inner surfaces being drusy with small and brilliant quartz crystals. Seams of white and translucent silica are also present. These quartzose nodules are the most abundant in the red rock. The dark brown and greenish portions of the dykes contain earthy nodules of a brilliant, dark, chrome-green color, and the same substance forms thin coatings upon the surfaces of small fissures. I regret that all the specimens from this vicinity were lost, as some of this peculiar green mineral was collected for examination.

The direction or trend of these intruded rocks appeared to be nearly north 20° east, south 20° west. An adjoining outcrop of sandstone strata trends north 45° east, and south 45° west; dip 54° to 55° towards the southeast.

By reference to the map, it will be observed that the eastern part of the Pass, from the summit to station 74, extends nearly parallel with, and skirts the foot hills of, the east and west range of mountains that divides the Great Basin from the valleys and slopes of San Fernando and Los Angeles. The hills on the right or south of the trail thus gradually rise to the elevated ridges of that range; while on the north the observer, after ascending about one hundred feet, stands on a wide and gentle slope, and has an unobstructed view of the Great Basin and the numerous barren ridges that rise from its broad surface like islands in the ocean.

The outcrops of igneous rock and the uplifted sandstone strata may be regarded as pertaining to this transverse chain of heights—the Bernardino Sierra—rather than to the Sierra Nevada. The central axis of this chain is granitic and metamorphic, as shown by the examination of the Pass of San Francisquito and Williamson's Pass, both of which are represented on the little Geological Map. The sedimentary formations of the Cañada, the Tertiary formations, and the more modern drift accumulations, are described in Chapter XIII and in the Itinerary.

CHAPTER XVI.

OBSERVATIONS ON THE SOUTHERN PART OF THE GREAT BASIN.

Boundaries of the basin as originally assigned.—Supposed dividing range.—Mojave river not a tributary of the Colorado.—Boundaries according to recent explorations.—Length and breadth.—Geological structure of the southern portion.—Aspect of the region from the crest of the Sierra Nevada.—Influence of the Sierra Nevada on the climate.—Lost mountains.—Elevation of the surface.—Aspect of the boundary ranges from the plateau.—Slopes.—Channels or valleys in the slopes.—Inclination of the slopes.—Lowest parts of the basin.—Mean elevation of the surface.—Geological structure of the lost mountains.—Metamorphic rocks at the Mojave.—Gray granite.—Porphyry and volcanic rocks.—Stratified formations, slopes.—Tertiary strata and drift.—Rivers and their action on the slopes.—Dry lake-beds.—Mirage.—Prints on the clay, like tracks.—Whirlwinds of dust.—Streams and springs.—Mojave river, its alternate appearance and disappearance.—Johnson's river.—Springs near the lost mountains.—Spring at the Mojave, and beyond.—Artesian wells.—Observations on the vegetation, and distribution of plants.

The extensive semi-desert region east of the crest of the Sierra Nevada, and lying between that chain and the mountains bounding the Valley of the Colorado to its sources, is described by Colonel J. C. Fremont as an elevated region, surrounded by high mountain ranges, including lakes and rivers, which have no connexion with the sea. To this broad area he gave the name *Great Basin*, and has defined its boundaries on the map which accompanies his report made in 1845.[1] According to this map, the Basin extends from near the parallel of 45° on the north to 34° 30′ on the south; and east and west from longitude 112° to longitude 120°, (near the parallel of 44°, which intersects the Great Salt Lake.) In a subsequent memoir,[2] accompanying a map of Oregon and California, published in 1848, the Basin is said to have an extent of about five hundred miles in diameter every way. The boundaries, however, as given on the map, are very different from those of the map of 1845; the southern limit of the Basin being supposed to be formed by a dividing range of mountains, extending nearly east and west along the parallel of 38°, called the "Dividing range between the waters of the Pacific and the waters of the Great Basin." The northern boundary was also represented as far south as the parallel of 41° 30′. The Mojave river was then believed to be a tributary of the Colorado, and was so represented. It was also laid down on the "Bureau Map" of 1850[3] as a continuous river from its sources to the Colorado, receiving, as a tributary, a stream called *Agua de Tomaso.* Under the supposition that the Mojave river drained into the Colorado, it was necessary to exclude from the limits of the Great Basin a large area at the south, thus leaving its southern boundary uncertain, although apparently formed by mountains seen in the north—the dividing range of the map of of 1848.

It having been ascertained by the Expedition that the Mojave is not a tributary of the Colorado, but that it ends in a dry lake nearly one hundred miles distant from the Colorado, and that a high and rugged range of mountains forms a barrier between the two rivers, the basin-

[1] Report of the Exploring Expedition to the Rocky Mountains, and to Oregon and to North California, House Doc. No. 166, 1845.

[2] Geographical memoir upon Upper California, to illustrate the map of Oregon and California. Senate, 30th Congress, Miscellaneous No. 148, p, 7.

[3] Map of the United States and their Territories, compiled in the Bureau of Topographical Engineers, Washington, 1850.

like character of that region is established, and there is little reason to doubt that the original statement, and the representation of the southern boundary of the Great Basin, was correct.

The boundaries of this region, as at present known, may, then, be stated as follows: On the north by the elevated ridges in which the tributaries of the left bank of Snake River take their rise, extending east and west near the parallel of 42°; on the east by the dividing ridge between the waters of the sources of the Colorado River and the Salt Lake, (the Wahsatch or Timpanogos Mountains,) and by the range between the Colorado and the Mojave, (Pai Ute range;) on the south by the Bernardino Sierra, from San Bernardino Mountain to the Sierra Nevada; and on the west by the Sierra Nevada.

The region thus bounded is a nearly triangular area, with its apex at the south in the Peak of San Bernardino, latitude 34° 30′, and its base nearly along the parallel of 42°—the dividing line between the Territories of Utah and Oregon; it also extends beyond and includes some of the elevated lakes of the crest of the Sierra Nevada. Its northeastern angle also extends into Oregon, including Bear River, the principal tributary of the Salt Lake. Its greatest length, measured from San Bernardino to its northwestern extremity, is nearly 700 miles; or, measured from Bernardino Mountain northwards along the meridian, is about 500 miles. The width, on the parallel of 42°, is over 500 miles; but south of the parallel of 36°, it is less than 180 miles. This narrow portion of the Basin, its southern extremity, reaches to within fifty miles of the Pacific Ocean; and although it is narrow, and of small extent when compared with the wide area between the Sierra Nevada and the Great Salt Lake, it is believed that the great characteristic features of arid barrenness, described by Frémont and others, are so strikingly displayed that a good conception of the whole area can be obtained from it. The geology, also, of the portion examined is so simple and well defined, and the structure of the region is such, that its geology may be regarded as an index to the geological structure of a wide area towards the north.

The first view of the surface of the southern part of the Basin was obtained from the Tejon Pass, at an elevation of about 6,000 feet. I stood on the crest of the Sierra Nevada, among oak groves, and near the margin of a forest of pines, but in the east a vast wilderness lay stretched out before me. It was not a wilderness of unbroken forest, but a desolate, barren region, parched and desert-like, its color that of dry gravel and sand. Here and there over the broad area were isolated ridges of barren rocks, rising in some places in conical peaks, flanked by long slopes, and in others extending for miles in a continuous series, one behind the other, until their outlines were blended with the distant horizon. Those persons whose eyes have only been familiar with green fields and wooded hills can scarcely form an adequate conception of the appearance of these bare mountains and the desert-like character of this inland region. Its surface is diversified only by these bald, barren, and rocky ridges, which rise at intervals, and present a strong contrast with the fertile, soil-covered ridges of the Sierra Nevada, watered by brooks and covered with verdure.

This strong contrast, or vividly marked change in the aspect of the country, is a grand demonstration of the climatal influence of the Sierra Nevada. This lofty chain of snowy peaks rises like a wall between the Pacific and the interior, and acts the part of dessicator to the moist winds that pour in from the ocean, abstracting the vapor that they hold, and condensing it upon the summits in fields of snow.

The moisture being thus abstracted from the winds, they pass inland over the surface of the Basin, and, instead of bearing clouds of vapor to be there condensed, they are in a condition to

abstract what little moisture may be offered by the loose and porous soil. The necessary conditions for luxuriant vegetation are therefore wanting; and the only plants found there have a most peculiar and extraordinary appearance, and are seldom seen in localities where the air is charged with vapor.

The barren ridges by which the surface of the Basin is diversified are much lower than the Sierra Nevada, and consist, apparently, of isolated peaks. The term *Lost Mountains* has, not inappropriately, been applied to these elevations; for they do not form continuous ridges, or an unbroken line of elevation, but consist of disconnected and rugged peaks, or very short ridges, rising at intervals of from five to twenty miles. They are surrounded on all sides by the long and gentle slopes which form the apparent plateau of the Basin.

These observations are made with reference to the mountains of the southern part of the Basin only, but they will doubtless truthfully apply to much of the northern and central portions. We are, however, aware that in the more extended and broad parts of the Basin to the northward there are long and lofty ranges—as, for example, the Humboldt Mountains, and others—which have all the characteristics of mountain chains. These are, however, believed to be but more enlarged and extended examples of the same peculiarities of structure that are observable in the minor ridges of the southern portion of the Basin.

The isolated and broken character of these ridges permits the traveller to avoid them by making frequent detours around their bases; and, in the event of the construction of a railroad over this surface, a nearly uniform grade can be obtained by winding about on the slopes.

These Lost Mountains, in the part of the Basin explored by the Survey, are separated by intervals of several miles; the principal ridges being from six to ten and twenty miles or more apart. Several which were visited were about eighteen miles north of the Bernardino Sierra. From the tops of these ridges the mountains further north appeared to be more numerous and nearer together; but this appearance was, in great part, due to perspective. It was difficult to determine the exact trend of the short ranges; but there is little doubt that the general or average direction is nearly north and south, or parallel with the eastern ranges of the Sierra Nevada.

The most striking feature of the Basin, next to the absence of drainage to the sea, is the great elevation of its surface, as compared with the extensive valley of the San Joaquin and Sacramento, or the slopes of the coast further south. The elevation was estimated by Col. Fremont to range from four to six thousand feet; the Great Salt Lake, near its eastern limit, has an elevation of four thousand five hundred feet.[1] The southern part of the Basin, however, although elevated, does not attain this altitude, but is considerably lower, as will be shown subsequently. The great elevation of the surface produces a great difference in the appearance of the bounding ranges, compared with their aspect from the plains at their seaward base. The eastern slope or ascent of the Sierra Nevada from the plateau is thus rendered very short, as compared with that towards the Pacific. Along the Bernardino Sierra, the surface of the Basin reaches, in many places, nearly to the summit of the chain, forming, in one instance, the crest of a pass. The Basin may thus be said to be *filled nearly to the brim.*

The surface thus elevated is not, as is generally supposed, a nearly level plain or plateau, but is rather a combination of slopes flanking the bounding mountains and all of the intermediate ranges, ridges, or Lost Mountains. These slopes are of slight inclination, but of uniform rates

[1] Report of Colonel J. C. Fremont.

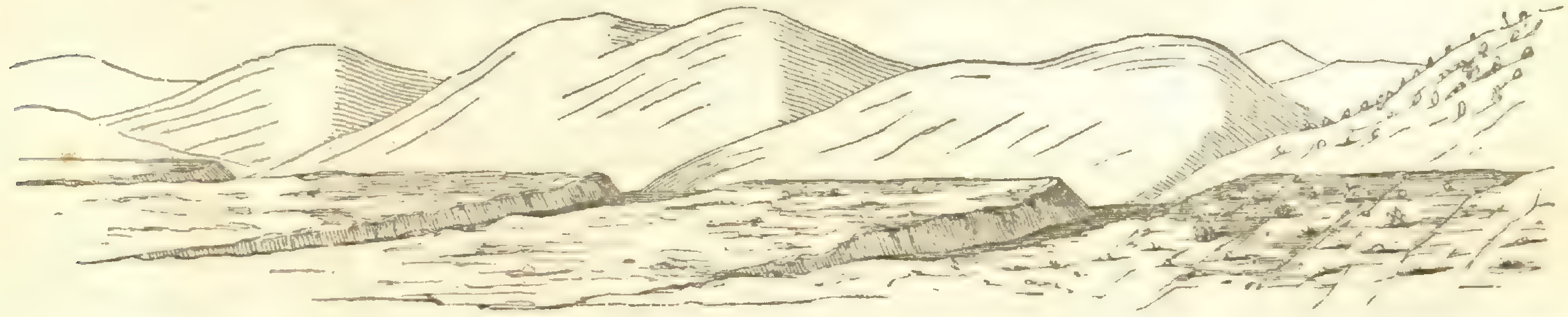
VALLEY IN THE SLOPE OF THE GREAT BASIN

of ascent, and their length is determined by the distances between the ridges or frame-work upon which the materials forming them are deposited.

When travelling on these extended slopes, the descent is scarcely perceptible, but becomes remarkably distinct where a distant and projecting angle of the mountains throws the slope outward, so that it can be viewed at right angles to its direction of descent. When these opportunities offered, the clinometer was used to measure the amount of inclination, and five degrees and six degrees was generally obtained as the result. The almost entire absence of vegetation sufficient to obscure the vision, and the clear air of that region, permit all the inequalities of the surface to be distinctly seen, even at great distances. The explorer of the Basin has, therefore, peculiar facilities for studying its topography. The gently ascending or descending slopes permit rapid travelling, and the occasional ridges and peaks offer inviting points of view.

The general characters and aspect of the slope from the Sierra Nevada, at the eastern end of the Tejon Pass, are described in Chapter VI. It is furrowed by a long valley of erosion leading from the Tejon, so that the view is limited on each side by the low banks or rounded hills formed out of the sedimentary deposits of the slope. A representation of this long valley, with its peculiar vegetation, accompanies this Chapter, View XI. The upper margin of the slope is four thousand feet in elevation, and it descends out into the Basin very uniformly. The slope at the Cañada de las Uvas is of the same character; the inclined surface or slope being continuous between the two places. The slope flanking the Bernardino Sierra is similar in its characters and very uniform in its surface. It extends northwards into the Basin until broken at intervals by the Lost Monntains, or an intersection with their slopes. This broad slope, extending for nearly one hundred miles, with a breadth of from fifteen to twenty is, in some respects, not unlike that which flanks the same chain on its opposite side and extends to, and under, the waters of the Pacific. It is, however, very different from that slope in its appearance and elevation, and is not so much modified or destroyed by the action of streams. On the side of the Pacific the streams are not only more numerous, but have a greater volume, and have excavated broader channels, which coalesce, and thus produce wide valleys; while, in the Basin, the streams are few, and widely separated; their channels are short and deeply cut, and extend but a short distance from the mountains.

In our journey over this inland slope, we were, in some places, obliged to descend with the wagons to its lower portions, in order to avoid these deeply-cut channels, which seemed like great grooves in the plain.



CHANNELS IN THE SLOPE OF THE GREAT BASIN.

The general form of these channels near the mountains may be illustrated by an outline sketch from my note book, taken from a point between Johnson's River and the Cajon Pass.

The regularity of the slope and its nearly uniform inclination was exhibited in the most striking manner in the descent from the summit of the Cajon Pass to the first camp on the Mojave River, a distance of 19 miles. It appeared very much like a plain when we were

descending it by the old Spanish trail; but, on arriving at the river, we found that we were 2,012 feet lower than the entrance to the Cajon at the upper margin of the slope. This descent of 2,012 feet in 19 miles is an average of 105 feet to the mile.

The descent, however, for a short distance from the summit is the most abrupt, being 497 feet in a little over two miles. Below that point the grades vary from 93 to 86 feet to the mile, and this is the most regular part of the slope; the descent in a distance of 17 miles being but little more than 1,500 feet. This amount of inclination is by no means constant for all the slopes of the Basin. Many parts of the northern slope of the Bernardino Sierra have a greater angle of descent, and this is especially true of many of the shorter slopes around the isolated ranges or Lost Mountains.

The meeting of opposite slopes necessarily forms a series of valleys, or basin-shaped depressions, between the bounding mountains and the Lost Mountains; also, between the latter. These are very numerous; in fact, the Great Basin must be regarded as made up of a series of smaller and local basins between the ranges. These conditions of the surface are made manifest along the whole eastern base of the Sierra Nevada, or wherever there is sufficient precipitation of water to form lakes or pools. The chain of lakes extending from Oregon south into California is found in a series of basins, or local valleys without outlets to the sea, or to the lowest parts of the Basin. They are independent basins of limited extent, and such valleys form the Great Basin by being grouped together.

In an attempt, therefore, to determine the average elevation of the surface of the southern part of the Basin it becomes necessary to consider not only the elevation of the upper margins of the slopes, but the altitude of the intersections of their lowest parts. The lowest point of the slope of the Sierra Nevada at the Tejon and Cañada de las Uvas, at its intersection with the adjoining slopes of the Bernardino Sierra and Lost Mountains opposite, was ascertained to be 2,380 feet; this being at the level of the dry lake, or level expase of clay generally found at the bottom of the local basins, when there is not a sufficient supply of water on the adjoining heights to keep the depression filled. The surface of this dry lake was seen to extend far towards the north. This dry lake bed may be regarded as the greatest depression of the southern part of the Basin, except the valley of the Mojave. This river appears to connect a descending series of local basins, and extends far to the north and east of its sources, and finally terminates in a dry lake covered with an incrustration of soda and salt. This dry lake has an elevation of only 1,137 feet, and is probably the lowest point in the whole extent of the Basin. It is a much greater depression than was supposed to exist, but it is possible that there are other very low points among the unexplored mountains and ridges between it and the Sierra Nevada.

The upper margins or limits of the slopes—their intersection with the ridges of the bounding mountains—is well defined, and to an observer on the surface of the Basin appear to be at nearly the same elevation at all points. A difference in the altitude is, however, shown by the instrumental results; but these differences are so slight that they may be disregarded in a general conception of the configuration of the surface of the Basin. The elevation of the several points from Walker's Pass around the margin of the Basin to San Bernardino may be thus stated:[1]

[1] I have in some cases added to the elevations as given in Lieutenant Williamson's tables, the observations having been made in the channels or valleys leading from the passes, and thus below the general surface. In some instances, also, the stations represented in the tables as at the foot of the mountains and at the surface of the Basin were at the lower end of the valleys excavated in the slope, and thus below its upper margin.

ELEVATION OF THE SLOPES OF THE BASIN.

At Walker's Pass	3,243
At Humpahyamup Pass	3,196
At Taheechaypah Pass	3,668
At Tejon Pass	3,987
At Cañada de las Uvas	3,186
At San Francisquito (Lake Elizabeth)	3,315
At Williamson's Pass	2,962
At Cajon Pass, at the summit, 4,676; two miles below,—the true margin of the slope	4,179

This gives, as the mean elevation of the margin of the slope, 3,467 feet above the sea. Comparing this with the elevation of the foot of the slopes, and disregarding the one great depression of the sink of the Mojave, we have 2,923 feet as the mean elevation of the surface; but, considering the opposite elevations of the slopes around the Lost Mountains, it must be a little over 3,000 feet. This may be regarded as the mean elevation of the surface around and between the ridges and mountains.

The basin-like structure is not confined to the interval between the Sierra Nevada and the bounding mountains on the east side, but is characteristic of these ranges also. According to the observations of Captain Whipple, the mountains between the Colorado and the Mojave, called the Pai-Ute Range, consist of many rugged ridges and peaks, with elevated valleys between them. A wide, local basin, with a dry lake at the bottom, is also found in the mountains east of the Mojave River, at the foot of the slope from the Cajon Pass. A similar structure is said to characterize the northern end of the Sierra Nevada. The Great Basin may, in fact, be considered as the flattened crest of a broad mountain chain. It is a succession of mountains and slopes, upon which the precipitation of water is so slight that the local basins are not overflowed so as to effect a drainage to the sea.

The barren rocks and the peculiarly regular slopes, free from trees and grass, and looking like broad ocean beaches, give the whole region the appearance of having been moulded to its present shape by the action of water. It seems almost as if it had but recently been covered by the sea, and that the waters had suddenly drained off.

GEOLOGICAL STRUCTURE OF THE LOST MOUNTAINS.

The mountains along the Mojave River, especially those near the foot of the slope from the Cajon, are very much broken, and appear to extend to the base of San Bernardino mountain, on the south, while on the north they form the flanks and outlying ridges of the Pai-Ute Range. All the ridges near the Mojave are barren and destitute of soil, and are very rugged and rocky. Their outlines are very irregular, and some of the subordinate ridges are entirely isolated from the main range, thus becoming *Lost Mountains.* When these are short and pointed they appear at a distance like a series of volcanic cones. The resemblance to cones and craters was so great, that when I was descending the slope to the Mojave I confidently expected to examine volcanic phenomena, and was disappointed to find nothing but granitic and metamorphic rocks.

The rocks on the right bank of the river consist of a belt of metamorphic slates, very compact, and so much changed as to resemble granite. They dip at an angle of 85 degrees, and are succeeded on the east by compact gray granite, which forms the mass of the ridge.[1] It is much fissured and traversed by enormous veins of feldspar and quartz in coarse masses. This granite is very rough on its surface, and, in places, is covered by immense blocks of the same

[1] See a small section, Chapter VI, page 64.

rock, piled together in such wild confusion as to become impassable. These accumulations somewhat resemble the heavy talus at the base of the mural faces of trap in Connecticut, but the blocks of granite are all large, and no small fragments or earth is seen. The ridge or bluff from which they appear to be broken is but little higher than the pile of ruins.

Several of the isolated ridges a few miles north of the south end of the Dry Lake, and many miles west of the Mojave, were also found to be composed of gray granite, traversed by veins or dykes of red feldspar and quartz. These feldspathic veins were so enormous and abundant that the whole slope around the elevation was colored red by the fragments. The gray granite was found to be rapidly disintegrating, and large blocks of it were found resting upon the surface.

It is doubtless the fact that erupted rocks, trap, porphyry, and the like, have played an important part in modifying the topography of the Great Basin. Two ridges of porphyry were found between the granite just described and the Sierra Nevada. The principal outcrop has a chocolate-brown or reddish color, and includes small white crystals. The rock is also colored in stripes or belts, like jasper, and is very hard. Erupted rocks also occur along the base, and in the passes of the Bernardino Sierra, but none were observed in the Sierra Nevada at the Tejon. It is probable that many other outcrops will eventually be found within the southern part of the Basin and north of the ridges mentioned.

It is probable, also, that extinct volcanoes and overflows of lava will be discovered at various points, on making detailed explorations. During Lieutenant Williamson's examination of the lower part of the Mojave River, he passed a conical butte of volcanic rock, which, from its nature and peculiar symetrical appearance, he was disposed to regard as a small volcano. He has described it in his report in the following words:

"About midway between the peak and the camp was a singular isolated hill, about 300 feet high. It was composed of very black volcanic rock, and its form that of a very symmetrical truncated cone, surrounded at its base by a circular horizontal bed of the same rock—the cone being in the centre. This bed was between two and three miles in diameter; its edges well marked, and rising from two to six feet above the surrounding gravelly plain."[1]

This volcanic butte was about twenty-five miles northeasterly from the Depot Camp on the Mojave, and I have indicated its position on the General Map. It is worthy of the attention of explorers who pass that way, and being near the Mormon road may be readily visited.

The observations on the isolated mountains, although limited, were sufficient to show that they are chiefly composed of granitic rocks. The compact granite appears to predominate, and no true gneiss or mica slate was seen. The rocks appear to be eruptive rather than metamorphic. The outcrop at the Mojave was the only locality at which metamorphic rock was seen. It is, however, found further north in the Pai-Ute Range. The general distribution of the outcrops of granite, and the frequent occurrence of a slight knob of rock, hardly perceptible at a short distance, led me to conclude that the subjacent granite was not far below the general surface of the Basin, and that its underground outline was exceedingly irregular, being cut into a series of valleys and ridges.

STRATIFIED FORMATIONS—SLOPES.

The sedimentary accumulations, resting upon the granitic rocks of the Basin, appear to be comparatively modern, or of the period of the Tertiary. These strata are nearly covered from view

[1] Report of Lieutenant R. S. Williamson, 8vo. edition, page 28.

by a thick deposit of detritus or drift—the debris of the rocks of the Basin—which forms nearly the whole surface, and constitutes the material of the slopes.

The only points at which the strata are exposed by sections are near the mountains, along the courses of the principal streams which reach the slopes, or in the banks of the numerous dry channels, in which no water appears to flow, at least, for the greater part of the year. There are many of these sections, but they are of slight depth, and do not extend far from the mountains. Some of these sections exhibit strata of sandstone in highly inclined positions, unconformable with the more recent materials composing the slope. At other places the strata appear to be conformable. The uplifted strata occur at several points, and are not only exposed in the valleys or channels of the streams, but rise above the general level of the slopes. They are principally sandstone and conglomerates, composed of the debris of granite or of volcanic rocks. Such strata are visible at the Cajon Pass, Williamson's Pass, Johnson's River, Cotton-wood Creek, San Francisquito Pass, and near the entrance to the Cañada de las Uvas. All these localities are described in the chapter on the Tertiary formations—Chapter XIII.

At other points around the slope of the Basin sedimentary strata, similar to these just described, are nearly horizontal, and do not appear to have suffered disturbance, but dip from the mountains with a gentle inclination, not exceeding five or six degrees, conforming to the slope of the surface. This is seen in the channel which leads out from the ravine of the Tejon Pass, and was also observed in some of the dry ravines in the slope between Johnson's river and the Cajon.

The materials which form the slopes are generally very different in their appearance from those of the strata, although, in many places, they are regularly stratified. They are, in general, coarser and unconsolidated, and appear to be formed from the fragments of the adjoining ridges. Thus, for a long distance from one of the isolated granite ridges, containing large veins of red feldspar, the surface was of the same color, owing to the distribution of the fragments. The gravel was chiefly composed of this feldspar at the distance of over two miles. So, also, the gravel of the slope around the ridges of porphyry was principally porphyritic; and, in fact, the nature of the rocks of the ridges of that part of the Basin can be determined by the debris of their slopes. In general, the upper portions of the slopes are composed of coarse materials, the finer and lighter debris being carried lower down before it is deposited. These detrital accumulations are believed to attain, at some points, a thickness of over five hundred feet; they thus constitute an important feature in the geology of the Basin.

There is much danger of confounding the thick beds of drift, when in regular strata, with the older stratified deposits of similar materials. The absence of good natural sections along the undisturbed parts of the Basin-slope often left me in much perplexity to distinguish between the drift and older strata. For example, at the entrance to the Cajon Pass, the sediments of the slope form a bluff, turned towards the Pass, in which the nearly horizontal layers are exposed to view for a depth of about seven hundred feet.

They do not differ very greatly in lithological characters from the more compact and consolidated strata in the Pass that are highly tilted, but appear to rest upon their upturned edges. Similar upraised strata were found along Cotton-wood Creek; there, the drift rests directly upon the edges, as shown in the little section, page 66, Chapter VII. Whether the strata of the slope of the Cajon, for the whole thickness of the exposure at the bluff, are composed of detritus alone, or in part of older sandstone, is not easily decided. More extended observations would probably remove the doubt. It is probable that the detritus agrees very nearly in its lithological char-

acters with the sandstone strata of the Cajon, for it was, no doubt, formed, in great part, from the abrasion of that sandstone.

The moulding, or form of the slopes, although to a great extent the result of oceanic currents and waves, is much modified by the action of the streams which descend from the surrounding mountains. It becomes evident, from an examination of the surface, that at certain seasons these streams become so much swollen that they descend in floods, and spread out, fan-like, over the basin in a multitude of shallow channels, bringing down great blocks of granite and vast accumulations of pebbles and earth, and spreading them out over the surface in great confusion.

These effects, and the general character of the results of the overflow of similar streams, were well shown by Johnson's River, which is a considerable torrent near the mountains; but a short distance below, all timber and green vegetation disappear from its banks, and the bed of the stream is broad, shallow, and perfectly dry. It is, however, paved with well-rounded boulders, and intersected by numerous minor channels, between banks of gravel and sand, evidently accumulated by the force of a torrent. Great logs of drift-wood are also found lying on the surface and imbedded in the gravel. The coarser parts of this alluvial drift are found nearest the mountains, and as the stream descends the slope, and becomes more shallow and diffused, the drift is smaller and more uniform in size, until it becomes merely gravel and clay. The finer portions of the drift are thus carried far out from their source, and are deposited on the lower parts of the slopes.

The tendency of all these mountain torrents appears to be towards a general diffusion over the surface, and not to the formation of a continuous channel. The character of the slope is thus preserved, although the result is a gradual filling up of all the depressions. In view of these facts, it becomes interesting to inquire how far the present condition of the surface is due to oceanic action, or to subsequent aqueous modifications.

DRY LAKES OR PLAYAS.

At the time of the overflow of the mountain streams, the excess of the water that is not absorbed in its passage over the extended slopes collects together in the numerous basin-like depressions formed by the intersection of opposite slopes. At such places temporary ponds or lakes of shallow depth are formed, and the lighter and clayey portions of the surface-drift that is brought down in suspension is deposited. We had evidence of these results in the numerous dry lake-beds that we passed over in the lowest parts of the valleys. One of these dry beds, lying between the Sierra and the range of the Lost Mountains north of the Bernardino Sierra, was seven miles in length and four or five in width. The soil was of fine clay, mixed with sand, the upper or surface layer being of nearly impalpable clay, which the water had left in the form of a brilliant pellicle. This was entirely dry, and not a trace of moisture could be detected. The surface was unbroken, and extended in a perfectly level plain, almost as smooth and hard as a polished table, and resembled the frozen surface of a lake. Such was the mirror-like polish of the thin clay pellicle, that the peaks of distant Lost Mountains, and small thorny shrubs on the margin, were as clearly and as distinctly reflected from the surface as they could be from a sheet of placid water, and it was, indeed, difficult to believe that water did not actually exist before me. The effects produced by simple reflection from a polished surface are sometimes confounded with those due to refraction, and they are indiscriminately called *mirage*. It is, how-

ever, probable that the peculiar illusive appearances of lakes of water, and the distortion of the images of rocks and trees, so common on plains and deserts, is the result of both reflection and refraction.

The dry lake-bed was connected by a narrow strait, also dry, with a much broader and longer lake-bed extending far to the north, among the Lost Mountains. Other similar dry lakes were found among the ridges east of the Mojave River and at the lower end of this stream, which appears to terminate in a depression of this kind.

On the hard, dry clay of one of these lake-beds I noticed very peculiar markings, like the tracks of an animal, extending for long distances in straight lines. These marks consisted of little depressions recurring at regular intervals; some of them appeared as if formed by the drawing or trailing of some irregular but light body over the surface when it was moist and yielding. The similarity between some of these marks and the trails of animals was very striking, and it was some time before their origin could be ascertained. They had been produced by branches of shrubs, with projecting limbs, that had been driven before the wind, the projecting limbs or knots having made prints at regular intervals by the rapid rotation of the branch. If such trails were covered up by a fresh deposition of clay, and should be afterwards exposed to view by splitting the layers, they would possibly be regarded as the tracks of a nondescript animal.

These broad and smooth lake-beds, unobstructed by vegetation, offer a free scope for the wind, which sweeps over and keeps them perfectly clean, not a particle of sand or loose dust being allowed to rest on the mirror-like surface. The phenomenon of high, slender, whirlwinds of dust was often observed when we were in the vicinity of these dry plains. They rise high in the air, and are very distinct in their outlines; they progress from one side of a lake-bed to the other, or travel over the more uneven slopes, and do not remain in a perfectly vertical column, but are curved and bent in various directions, conforming to the currents of the air.

A portion of the clay forming the surface of one of these dry lakes was preserved and examined by the microscope, without finding any organic remains. It appears to consist principally of clay and fine sand, and is a stratum that is retentive of moisture. This fact is important in connexion with the discussion of the probability of obtaining water in the Basin by boring. According to the descriptions of Lieutenant Parke and others, the dry lakes, or *Playas*, of the region south of the Gila, in Sonora, are very similar to those of the Basin, and doubtless have a similar origin. The region in which they are found is in many respects very much like the southern end of the Great Basin.

STREAMS AND SPRINGS OF THE SOUTHERN PART OF THE GREAT BASIN.

The dessicating influence which is exerted upon the ocean winds, in their passage towards the interior, by the lofty summits of the Sierra Nevada is so great as to prevent the precipitation of much moisture upon the barren ridges of the central parts of the Basin, or upon those ridges which are near the eastern foot of the snowy ranges.

A portion of the water which is thus intercepted in its passage to the interior, and deposited on the Sierra Nevada, flows down in streams on the interior slopes, and reaches the borders of the Basin. The quantity thus discharged into the interior is by no means small, but is not commensurate with that which flows down on the seaward slope of the chain. On the Basin side, the streams are few, at great intervals, and are generally short, and of small volume; on the other, they are numerous, ramified, and by constant confluence produce long and formidable

rivers. In the northern part of the Basin a few streams of considerable length are found, such as the Humboldt, Bear River the tributary of the Salt Lake, and Sevier or Nicollet River; but when we compare their number and extent with those of the much more limited valley of the Sacramento and San Joaquin, on the opposite side of the Sierra, the extreme aridity and want of natural irrigation of the region becomes apparent. The principal streams which flow into the Basin, in the section which came under our observation, are the Mojave, Johnson's River, and Cotton-wood Creek. There are others of small extent at the entrance to Taheechaypah Pass, the Tejon Pass, and one between Cotton-wood Creek and the Mojave.

The Mojave River is one of the principal streams of the Basin, and rises among the ridges of San Bernardino Mountain, whence it flows northward along the western base of the low granite range which forms a part of the Pai-Ute range separating the Basin from the Colorado. This river has been supposed to be a tributary of the Colorado, but the survey of Lieutenant Williamson has shown that it has no outlet, and that it sinks away in a dry, basin-shaped depression, or lake-bed, about one hundred miles from its source. The first point at which we struck this river was about twenty miles northeasterly from the Cajon Pass, where the Spanish trail crosses the stream. At this point the river was a broad but very shallow stream, flowing rapidly in a bed of sand, without any vestige of rocks or pebbles, except an occasional grain of granite. The broad, sandy bed resembles that of the Chowchillas River far down in the plain. The immediate or first banks of the stream are low and sandy, and evidently subject to overflow, as was shown by great accumulations of river-sand on their surfaces. This bank, or "river-bottom," is thickly wooded with cotton-wood and sycamore; (or the plane tree,) and an abundant growth of willows. I found the temperature of the water on the 21st of October to be 70°, air, 78° in the shade.

The phenomena of the complete absorption and final re-appearance of streams are well exhibited by this river. It alternately sinks in the sand, and re-appears suddenly as a running stream, at points several miles distant; this is repeated several times along its course before its final absorption. This stream, and others that flow below the surface of the ground for a part of their course, are sometimes observed to increase in volume very suddenly, and in those portions of the stream between two points of subterranean current. This peculiarity was noted by Mr. Smith, one of the party that journeyed down the Mojave. They crossed the bed of the stream and found it perfectly dry, and on returning by the same trail, three days after, water was running over a foot in depth. A short distance above the channel was perfectly dry.

It is very probable that the phenomenon of the re-appearance of these streams above the ground, after they have once sunk, is due to the uneven surface of underlying impervious rocks, which, in some places, come so near to the surface that the subterranean water is forced above it. A sudden increase in the volume of water flowing in such places, although separated from the upper portions of the main stream by several miles of dry sand and gravel at the surface, would naturally be the result of a rise in the head-waters of the stream, produced by rains or rapid melting of snows in the mountains.

It was evident from the appearance of the dry portions of the channel of the river, that at certain seasons it is much swollen, and that it flows in a continuous, unbroken torrent over the portions of its channel that become dry during the summer.

Johnson's River rises in the Bernardino Sierra, about half-way between Williamson's Pass and the Cajon, and was named after one of the men who was sent forward to find water. At the point where it was crossed by the Expedition, it was about fifteen feet wide and from eight

to ten inches deep. The water was clear and cold, and flowing rapidly over a bed filled with boulders as large as the head. It was evident, from the character of the channel, that at certain seasons a great body of water flows down to the slope and is spread out upon it.

Cotton-wood Creek is of much less importance, and at the time of the examination was not a flowing stream ; but the channel gave evidence of occasional torrents of great volume.

The stream called *Agua de Tomaso, or Agua de Tio Mes,* which is generally represented on the maps as a tributary of the Mojave, is merely a spring of bitter water, and does not form a stream over one hundred yards in length.

Nearly all of the streams which descend from the mountains into the Basin are confined to the cañons or channels of the slope, and they do not extend far out from the mountains or spread out over the slopes. Those which are of great volume, or are swollen by sudden rains or the melting of snow, and thus reach the open plain of the slope, become divided up into numerous shallow beds, and are soon completely absorbed by the sand. This was well exhibited by Johnson's River, and others. The action of these rivers upon the slopes of the Basin, and the formation of temporary lakes at the base of the slopes, has already been considered.

Springs.—Several springs were found in different parts of the Great Basin, but generally in the vicinity of the Lost Mountains. It would appear that the greater part of the water which is supplied to the Basin by the rivers or by rain sinks immediately away, far below the influence of the dry atmosphere, in the deep and loose gravelly materials which form the slopes and occupy its depressio s. This water may not reach the bed-rock of granite, but may pass through the porous strata until intercepted by an impervious stratum, and be thus collected and retained in underground reservoirs. From these stores the water occasionally reaches the surface and forms springs. From the nature of the surface of the Basin, and the uneven character of the underlying rocks, we may venture to conclude that there are many springs throughout its extent. The short excursion made by Lieutenant Williamson and myself, from the Tejon towards the Mojave, resulted in the discovery of no less than *five springs* within a linear distance of twenty-five miles. These springs were well known to the Indians, and we were guided to some of them by a Mojave, who probably had often visited them in his journeys to and from the settlements south of the Cajon Pass.

At the time of our visit to these springs all the low grounds were completely dry, and there did not seem to be a possibility of finding water in such barren and desert-like regions. At a distance, however, of about eight miles from the last water of the Tejon Pass, a green spot of grass, six or eight yards in diameter, was found, and in the centre a spring of cool, delicious water. Its temperature was 64°, and the air 90°. The ground was raised about it in a slight mound, which is probably a result of the accumulation of vegetable matter and sand. It is about one mile distant from the base of the first Lost Mountain, and, by the aneroid barometer, is 1,000 feet below the margin of the Basin-slope. Numerous masses of compact white clay, and an unusual amount in the soil, indicated the proximity of underlying clay beds. There was no outcrop of strata, but it is probable that they rise near to the surface.

Six miles further east, another spring rises at the base of another rocky ridge. It is not, however, in the lowest ground, as it is at the upper margin of the long slope flanking the ridge. It forms a pool about six feet in diameter, containing an abundance of good water, and a small, trickling stream flowed from it for a few yards. This spring had been much resorted to by Indians, as the bones of horses and mountain sheep were found around it. Three other springs, similar to those described, were found, at intervals of from six to ten miles, at different points

among the Lost Mountains, all of which appear to be constant and capable of supplying a large quantity of water.

At our Depot Camp on the Mojave River, the water we used was not obtained from the stream, but from a large spring gushing out of a bank elevated several feet above the river, and three or four hundred yards from it. This spring forms a pool about twenty feet in diameter, and from one to one and a half feet in depth. The bottom is sandy, and a stream of clear water flows rapidly away from it. This water is warm; and on cold, frosty mornings, before the sun has risen, is enveloped in a cloud of fog, or "steam." On the 7th of October, at 2 p. m., I found its temperature to be 73° F., the air being 60°. On the 8th, at daylight, air 36°, water 72°, and the ground around the spring covered by frost.

There is another large spring on the Spanish trail, not far from the lower end of the Mojave, called *Agua de Tomaso*, or *Agua de Tio Mes*. This is a pool about six feet in diameter,[1] from which bitter water flows for about one hundred yards. Three or four smaller springs are found in the vicinity, or within a radius of fifty yards, and all of them are fringed with grass. These springs are on the side of the hill, and are constant.

Other springs in this vicinity, and further north, are mentioned by Colonel Fremont.[2] Some of these were salt, but others, beyond the stream of bitter water called *Armagosa*, were fresh and excellent. The camping ground called *Archilette* is in a basin well supplied by springs, bordered by willows and grass; between this place and Las Vegas there is another, which Colonel Fremont called Hernandez Spring. The springs called Las Vegas are described as large and slightly warm, the temperature being 71° to 73°. They form two narrow streams of clear water four or five feet deep, flowing with a quick current. It is probable that these last springs are without the crest, or divide, of the boundary of the Basin, being near the sources of the Rio Virgen, a tributary of the Colorado.

The configuration of the surface of the Basin, and its subordinate interior basins of small extent, is favorable to the production of springs, and to subterranean currents of water. This statement is verified by the number and extent of the springs that have been described. In nearly every case the camping ground of the traveller is not on the bank of a brook or river, but at springs or pools of water. Even the Mojave, below the point where it sinks for the first time, may be considered as a chain of springs; for the phenomena of its subterranean flow and re-appearance at distant points are precisely those of springs, which, in fact, are but outbursts of underground rivulets or brooks, or the outlets of a collection of water in a basin-shaped depression, forming a subterranean lake. These natural fountains of water are, indeed, the only dependence, for days together, of the traveller of those semi-desert regions. No shaded groves or running streams, bordered by a rich growth of timber, greet his eye; but in some hidden valley, walled in by brown and sombre ridges, he sees a dark spot on the parched and sandy surface, and singles it out as his camping place for the night, recognizing in the familiar tuft of willows indications of the water he so earnestly desires.

POSSIBILITY OF OBTAINING WATER BY ARTESIAN WELLS.

The facts which have been presented regarding the rivers and springs of the Basin are sufficient to show that a large and constant supply of water is thrown into it from the interior slopes of the Sierra Nevada and the Bernardino Sierra.

[1] According to Lieutenant Williamson, who visited it.

[2] Report of an Expedition to the Rocky Mountains, Senate Doc. 174, p. 263–266.

In addition to the supply from the mountains, a considerable quantity of water is occasionally received in the form of rain, which partly compensates for the loss by evaporation from the surface. Thus, during our sojourn at the Depôt Camp, at Ocoya creek, in August, the party in the mountains, near Walker's Pass, experienced a heavy rain, by which they were thoroughly drenched. It appeared to rain quite as hard upon the surface of the Basin, and its effects were afterwards seen, although at a distance from the mountains the fall did not appear to have been very great.

The evidences of the existence of strata of clay underlying the slopes are of great importance to the determination of the question as to the possibility of obtaining water from ordinary wells or by boring. Such strata may be regarded as comparatively impervious to water; and as they occupy the hollows and basin-shaped depressions between the Lost Mountains, we have most of the conditions necessary for the successful construction of Artesian wells. These clayey strata doubtless alternate with beds of sand and gravel, and subterranean waters may either flow between them or at the bottom of the whole series next to the underlying granite. We have seen that the underground surface of the granite must be exceedingly irregular. It doubtless presents a series of ridges and valleys similar to those exhibited in the portions elevated above the general level of the sedimentary accumulations. These sedimentary strata do not lie in horizontal planes, but are more or less uplifted; and even when they rest undisturbed they dip gently away from the elevated ridges, as is seen along the base of the Sierra Nevada and Bernardino Sierra wherever sections are exposed. We may therefore conclude that the sediments conform in their stratification very nearly with the shape of the valleys, so that the lowest points in each are nearly in the same vertical line.

These conditions should be carefully studied before commencing to bore for water, and it may be regarded as a general rule that the shape of the surface is, in the main, correspondent with that of the subjacent granite. In other words, the principal valleys or depressions in the Basin correspond with the lowest places in the granite.

In these lowest places both the surface and subterranean waters collect; and in the rainy season, when the streams are swollen in the mountains, or during heavy rains, the temporary shallow ponds are formed, which leave the level expanse of clay or *playa* on drying up. As in these low places only the finer portions of the slope are brought down and deposited, it is probable that the clay extends to a great depth, or at least to the surface of older sediments or the bed-rock of granite, without being mingled with coarse or rudely stratified materials. All these conditions are favorable to the construction of Artesian wells, and it is probable that water can be obtained at distances convenient for railroad purposes in the portions of the Great Basin examined by the Expedition.

In selecting places for boring operations it will be necessary not only to regard the form of the surface of underlying rocks, and the dips of the impervious strata, but attention should be given to the presence and position of ridges or dykes of erupted rocks, which may greatly modify the general direction of the valleys in the granite, and also act as walls or barriers to the flow or percolation of the subterranean water. Much assistance in determining the best place to commence operations may be obtained by observations upon the scanty vegetation. I observed that in some of the low places, especially where water had been standing, that the tufts of "bunch-grass" were not only more numerous, but more full and luxuriant, and retained some traces of green at their roots, while those on the higher parts of the slopes were completely dried. Other aids in discovering water will be found in currents of cool moist air, and in the

temperature of the surface, for any moist surface exposed to the dry airs of that region suffers a rapid reduction of temperature in consequence of the evaporation.

The moist, cool air from springs or moist places is quickly perceived by the senses, especially as the greater part of the atmosphere is dry and warm. Observations at night therefore, with the hygroscope, and of the temperature of the ground in different depressions would probably lead to interesting results.

DISTRIBUTION OF PLANTS ON THE SURFACE.

Although the greater part of the surface of the Basin is without trees or shrubs of any magnitude, some portions of the slope, especially near the Cajon Pass, are rendered picturesque by a growth of cedars or junipers and the yucca or "Spanish bayonet tree."

VEGETATION OF THE SLOPE OF THE BASIN NEAR THE AJON PASS

This plant grows to a great size, and forms a thick grove in some places, giving a tropical aspect to the landscape. It was observed in the channel leading to the Tejon Pass and to the Cañada de las Uvas,[1] and at various points around the margin of the Basin; also on the slopes flanking the Lost Mountains. Several of the trees near the Spanish trail were eighteen or twenty inches in diameter at the base, and twenty to twenty-five feet high. It generally rises in one straight trunk or column, from three to fifteen feet high; but near the Cajon it branches out and attains a great breadth of top. Green leaves or spines are chiefly confined to the last two or three feet of tops of the plants, or at the ends of the short and thick limbs. The leaves

[1] See View XI.

lower down become dry and yellow, and then hang downwards over the trunk, overlapping like shingles. Every leaf is as sharp as a thorn at the end, and is very stiff.

The unequal distribution of plants upon the surface is worthy of notice, and is distinctly observable along the Spanish trail, which traverses the long slope from the Cajon to the Mojave river. In descending this slope a succession of belts or zones are passed, in each of which some particular plant or group of plants predominates, and determines the aspect of the surface.

At the summit of the Pass, the dwarf oaks and deciduous shrubs are the most abundant. They are succeeded by a belt of low, dwarf cedars, which spread out over a large surface of ground, but seldom attain a height of over fifteen feet. Larrea Mexicana is found mingled with them. Lower down on the slope the cedar is replaced by the peculiar yucca; and towards the foot of the slope, at the Mojave, this gradually disappears, and the surface supports a growth of low thorny shrubs, which are almost without leaves, and seem to consist of a mere aggregation of thorns. These plants exist in great variety, and may be found among the other plants on almost all parts of the slope. At the foot of the slope, along the river, we find cotton-woods, willows, and the mezquit.

There is not any sufficiently well-marked difference in the chemical constitution of the soil at the parts of the slope occupied by different plants to authorize the supposition that their unequal distribution may be thus explained. The only variation appears to be, that the upper portions of the slope are of coarser materials than the lower portions. The explanation of this phenomenon of distribution of the plants in successive belts or zones is doubtless to be found in the climatic conditions which exist at the different altitudes. The variation of the humidity of the atmosphere at the different elevations is probably the principal modifying cause.

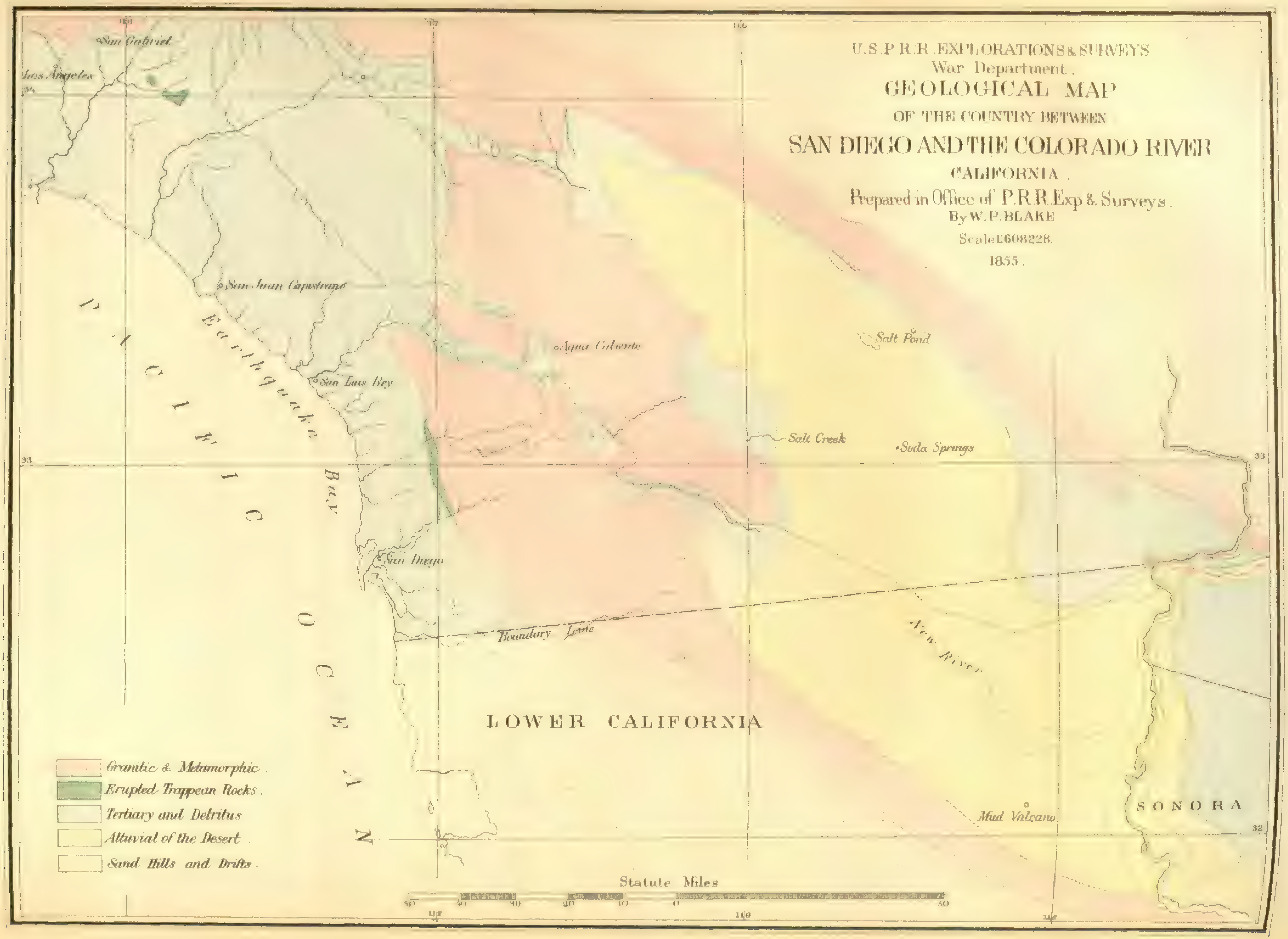
CHAPTER XVII.

THE COLORADO DESERT.

Extent and boundaries of the desert.—Desert beyond the colorado.—Surface of the desert.—Hard clay.—Slopes.—Undulating hills of sand.—Level and higher plain covered with pebbles.—Silicified fossils.—Polished surfaces of the pebbles.—Polished and blackened rocks.—Abrasion and polishing produced by driving sand.—Elevation of the surface of the desert.—Depression of a portion below the sea-level.—Terraces.—New river.—Geological formations.—Metamorphic rocks.—Alluvium, its extent and lithological characters.—Fossils.—Tertiary strata.—Fossils.—Ancient lake.—Former extension of the gulf to San Bernardino mountain.—Origin and formation of the lake.—Elevation of the former shore.—Calcareous depositions from the water of the lake.—Analysis of the travertin of Pilot Knob.—Sand-hills.—Position of the sand-hills determined by the terrace.—Outline of the sand-hills.—The sand not an obstacle to the construction of a railroad.—Sources of water on the desert.—New river.—Cook's well.—Alamo well.—Soda springs.—Salt lagoon.—Distances between localities of water.—Necessity for wells.—Artesian wells.—Agricultural capabilities of the desert.—Bottom-land of the Colorado and Gila.—Cohuilla villages.—Necessity for irrigation.—Irrigation by New river.—Climate and winds.—Clearness of the air.—Colors of distant mountains.—Mirage.—Effect of the climate on the vegetation.

The region of country known as the Colorado Desert is a long plain or valley west of the Colorado River, near its mouth. It extends from the base of Mount San Bernardino to the head of the Gulf of California, and is separated from the coast-slope by the Peninsula Mountains. The limits of the plain on the north and northeast are determined by the ranges of mountains which extend from San Bernardino Mountain to the mouth of the Gila and beyond into Sonora. On the south and east, the Desert is bounded by the Colorado River and the Gulf. The area thus bounded is a long and nearly level plain, extending in a northwest and southeast direction, from latitude 34° on the north to the parallel of 32° on the south. Its greatest length in this direction, from the base of San Bernardino Pass to the Gulf, is one hundred and eighty miles, or, measuring from the base of the Pass to the mouth of the Gila, it is one hundred and forty miles. Its greatest width is about seventy-five miles, measured in a north and south direction along the Colorado River, between the head of the Gulf and the mountains north of Fort Yuma. The plain narrows as it extends back from the Colorado River, and opposite Carrizo Creek its width is reduced to between sixty and seventy miles, and still further westward, near to its extremity at the San Bernardino Pass, it will not average over twenty-five miles. These measurements are approximate, and give for the whole area, west of the Colorado, about 8,250 square miles, or, including a portion of the plain beyond the river, about 9,000 square miles. A similar Desert borders the Colorado River on the east side, and appears to extend for a long distance up the Gila, and to reach to the foot of a range of mountains in Sonora, but, as the exploration did not extend so far as to ascertain the boundaries, it is not included in the description. The coloring on the map is, however, extended so as to indicate the geological character of that part of the region near the river.

The exact parallelism of the valley of the Desert with the coast, and with an intermediate line, formed by a succession of the narrow valleys of Vallecito, San Felipe, Warner's, and the San Luis River, and also with the Bernardino Pass, is worthy of notice. It is strikingly exhibited by the distribution of the colors of the map. They clearly mark out the direction and


U.S.P.R.R. EXPLORATIONS & SURVEYS
War Department.
GEOLOGICAL MAP
OF THE COUNTRY BETWEEN
SAN DIEGO AND THE COLORADO RIVER
CALIFORNIA.
Prepared in Office of P.R.R. Exp & Surveys.
By W. P. BLAKE
Scale 1:608228.
1855.
San Gabriel
Los Angeles
San Juan Capistrano
San Luis Rey
San Diego
Agua Caliente
Salt Pond
Salt Creek
Soda Springs
Earthquake Bay
PACIFIC OCEAN
Boundary Line
New River
LOWER CALIFORNIA
SONORA
Mud Volcano
Granitic & Metamorphic.
Erupted Trappean Rocks.
Tertiary and Detritus
Alluvial of the Desert.
Sand Hills and Drifts.
Statute Miles

prevailing trend of the granitic elevations to which the region owes its configuration. A predominant northwest and southeast trend of the principal lines of elevation is said to characterize the mountain ranges along the Gila River.[1] It is also visible, in detail, in the range on the north of the Desert, where the ridges project in a series of overlapping points, forming long and re-entering angles. This appears to result from a series of parallel ridges succeeding each other from west to east, and overlapping towards the southeast. This composite character will be found in nearly all of the mountain ranges of California; but, so far as my observations have extended, this is the only instance where the overlapping of the ridges is towards the southeast; it is generally the reverse, or towards the northeast.

ASPECT OF THE SURFACE OF THE DESERT.

Before I reached the surface of the Desert I had been accustomed to regard it as a vast plain of gravel and sand, and supposed that the latter was so deep as to impede the progress of animals and wagons. This, I believe, corresponds with the general impression regarding the Desert. Instead, however, of the whole plain being composed of loose and sandy materials, a great part of it is formed of a compact, blue clay, which has a smooth, floor-like surface, so hard that the passing of mules and wagons scarcely leaves a mark upon it. This hard clay is principally confined to the central and lower parts of the Desert, but at some places reaches to the foot of the mountains. It appears to be the extension of the alluvium of the Colorado, and reaches from its banks, and from the head of the Gulf, as far as the base of San Bernardino Mountain. Its breadth of surface is variable, but the road from the mouth of the Gila to Carrizo Creek is upon it for nearly the entire distance. Extensive portions of the Desert are, however, very different. We find in some places long and gentle slopes bordering the mountains, nearly as in the Great Basin; and in others, level plains, nearly or quite flat, and raised above the general level of the alluvium or clay. To the traveller, the surface appears nearly level, but here and there, gentle, local undulations are found, and are caused by accumulations of blown sand mingled with a portion of clay and partly hardened, so as not to be shifted by the wind. Other and more recent accumulations form long belts of hills with rounded outlines, and consist entirely of clean, dry sand, which flows from the hand like water, and is at the mercy of the wind. The surface of the slopes is variable, but, in general, is gravelly and firmly impacted, so that it is easily travelled over with wagons. A portion of the slope on the western side of the Desert, between the emigrant road and the Cohuilla villages, is strewn with masses of rock, from four to twelve and fifteen inches in diameter; but this was the only point at which transported fragments were found of such great size. The central or lower portions of the Desert are entirely free from them. The upper plain, or that part of the Desert north of Pilot Knob, and at an elevation of about thirty feet above the clay formation, has not the character of a slope, but is a true plain, with a uniform surface of pebbles, and but little or no fine gravel or sand. From Fort Yuma this plain is seen on all sides, extending back to the base of the mountains, and is a perfectly barren waste traversed by the Colorado and the Gila; their channels and borders of fertile land being marked by green vegetation. South of the mouth of the Gila, the plain approaches near to the Colorado on its eastern bank, and forms a long bluff or terrace, similar to that north of the stream, at its bend between the Gila and Pilot Knob. This plain may be considered as the true or most perfect desert, being without soil, vegetation, or water, and the source from which the greater part of the sand is derived.

[1] W. H. Emory, U. S. Top. Eng., Rep. Ex. Doc. 30th Cong., 1st sess., p. 98.

The surface of this plain is paved with small pebbles of various hard rocks, principally of volcanic origin, including variously colored porphyries, agates, and carnelians. Specimens of silicified wood are also numerous. All the pebbles are beautifully rounded and water-worn, showing that they have long been subjected to attrition, and indicating that they have been transported for great distances. In some places the pebbles are so thickly spread that the surface is entirely formed of them, and no sand or soil is visible. They are also packed together so closely, and lie so even, and are so uniform in size, that the surface is like a floor. Indeed the pebbles look as if they had been pressed into a yielding surface by a heavy roller.

These pebbles have a peculiar polished and brilliant surface, looking as if they had been oiled or varnished. The effect produced by the reflection of the sun's rays, from a plain covered with these polished convex pebbles, can scarcely be imagined; each one gives back a ray of light, and the ground seems paved with gems. It is somewhat like the glittering reflection from the ripples of a sheet of water.

All this polishing is undoubtedly produced by the constant action of loose sand upon the surface, when driven by the wind. The fact that all the fine sand or dust is removed from between the pebbles near the surface, while it is abundant a few inches below, indicates that the winds have gradually blown it away, leaving the heavy pebbles behind. They thus protect the sand that lies below them. Indeed, the protective power of this surface of pebbles is worthy of remark; for, if they were removed, it could not be long before the thick, underlying strata of sand would be blown away by the impetuous winds of that region. The equivalent of this plain of pebbles does not appear to exist on the western side of the Desert, or at least on that part of it north of Carrizo Creek, unless we so regard the flat-topped hills formed by the strata in the valley of Carrizo Creek. These are not horizontal, and do not form a continuous plain, but are surmounted by a pebbly drift very similar to that north of Pilot Knob, although coarser, and mingled with larger blocks. A great number of these pebbles are silicious, and full of fossils. These are apparently of the Palæozoic and Secondary periods, and, also, of the Tertiary. Many of them are very beautiful; the sections of the silicified shells or corals being visible on the rounded and polished surfaces. Several of these pebbles were obtained on Pilot Knob, but specimens of much greater interest and beauty were afterwards collected by Major George H. Thomas, U. S. A., commanding at Camp Yuma, and presented to me.[1] Most of the fossils are corals, and are probably Carboniferous.

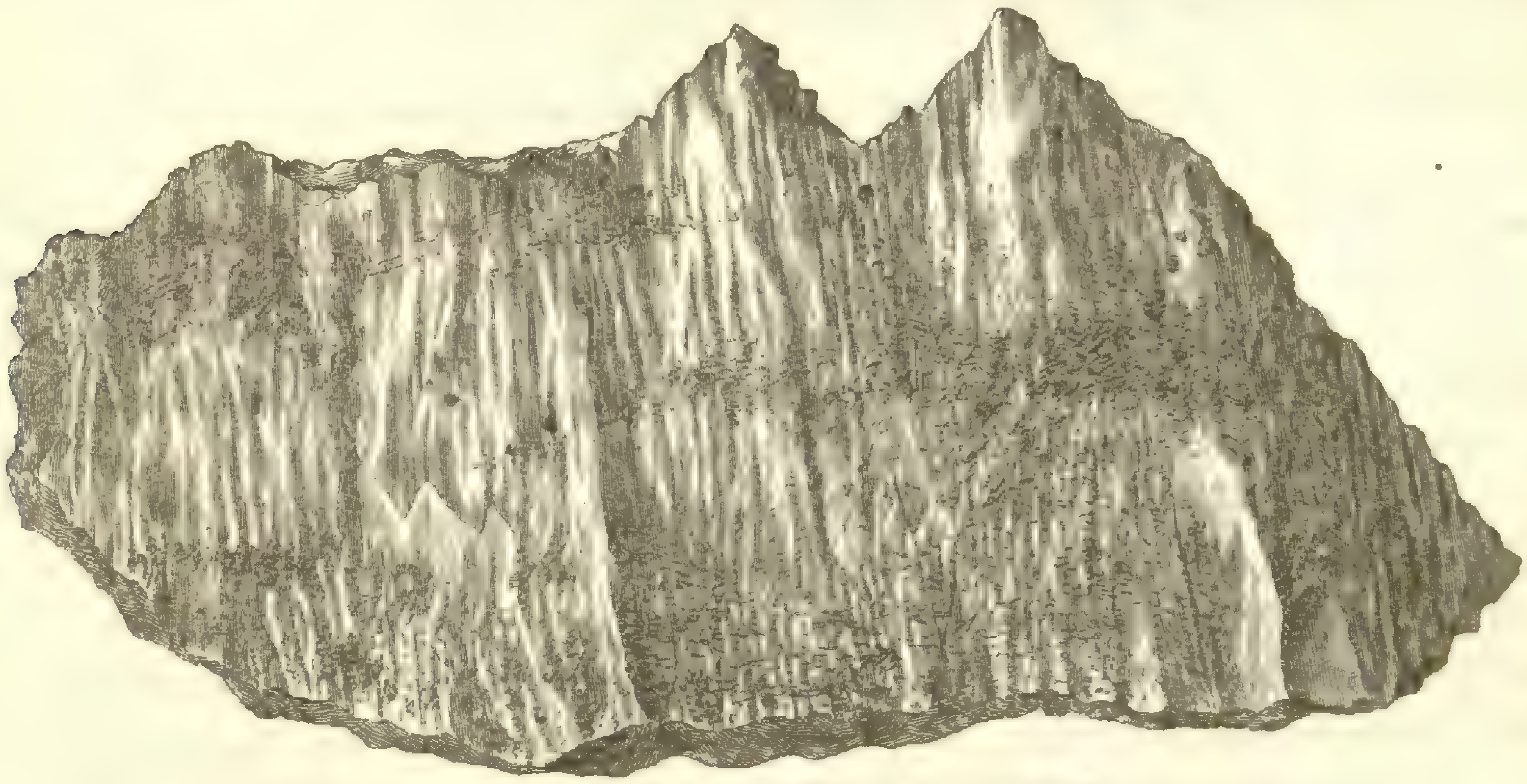
The rocks around the Desert, especially those on the northern side, rising above the pebbly plain, partake of the general polishing. Pilot Knob is, perhaps, one of the best examples. The surfaces are not merely polished, but are discolored; a large portion being as black as ebony, and yet having the ordinary gray color of granite or gneiss within. A dark, blackish-brown is a common tint, but it is so deep that it is impossible to decide upon the nature of the rock without first breaking off a fragment. The discoloration is confined to the surface, and does not extend to a perceptible depth. It is found alike on the rocks, pebbles, and specimens

[1] One of these pebbles of a dark color has a conical cavity in one side nearly half an inch deep, and marked on the sides by longitudinal septæ. It is the silicified imprint or portion of a coral allied to the *Cyathophyllæ*. The structure of the coral is very clearly shown. It is without transverse septæ, and this indicates its modern or Cretaceous age. In another specimen the septæ are distinct, and it is probably Carboniferous.

One of the specimens, of a dark chocolate-brown color, is filled with small, white fossil shells, discoid, and apparently thickest in the centre, like *Nummulites*. Some of the sections exposed on the worn surface are like those of *Fusilina*, to which it is probable the fossils may be appropriately referred. The pebbles containing stems of encrinites are the most numerous. It is regretted that it has not been possible, since the specimens were received, to prepare sections and give them that close examination which they deserve. Specimens are deposited in the collection, No. 401.

of silicified wood. A pepple of white quartz had a red surface, looking as if it had been painted. A peculiar "inky blackness" of the rocks around the Egyptian Deserts has been noticed by travellers, and is, doubtless, similar in its origin. Humboldt observed that the granite along the Orinoco had acquired a grayish-black coating wherever it had been in contact with water,[1] and that it was not found along those rivers which have black or coffee-brown waters. The source of the coloring is thus indicated to us, and it may be that the rocks along the Colorado, and the pebbles of the Desert, received, during their submergence, a coating of organic matter, which, under the burning rays of the sun in that almost rainless region, has become a perfect lacquer. A similar discoloration was observed within the limits of the Great Basin, on the banks of the Mojave, several feet above the present reach of the stream. The outcrops of gneiss were so black that the rock could not be recognized without breaking it.

The wonderful abrading effects produced by the moving sand in the lower part of the Pass of San Bernardino, near the margin of the Desert, are described in Chapter VIII. A figure is also given illustrating the effect of the sand upon vertical surfaces of the rock, where it was composed of minerals differing in their hardness, as in quartz and feldspar. The effect of this driving sand is, however, much more vividly shown at the locality by the grooved and polished surfaces of the rock. Specimens of the rock, abraded and smoothed in this manner were



GRANITE FURROWED AND POLISHED BY MOVING SAND.

obtained, and the attempt has been made to represent the surface by a figure, but with indifferent success. The number of small grooves and channels on the sides of the principal grooves could not be fully represented.[2]

[1] I find the following note upon this subject in Humboldt's *Views of Nature*, *Bohn's Edit.*, 1850, page 141. In the Orinoco, and more especially at the cataracts of Maypures and Atures, (not in the Black River or Rio Negro,) all blocks of granite, even-pieces of white quartz, wherever they come in contact with the water, acquire a grayish-black coating, which does not penetrate 0.01 of a line into the interior of the rock. The traveller might suppose that he was looking at basalt or fossils, colored with graphite. Indeed, the crust does actually appear to contain manganese and carbon. I say "appears" to do so, because the phenomenon has not been thoroughly investigated. Something perfectly analogous to this was observed by Rozier, in the syenitic rocks of the Nile, (near Syene and Philæ ;) by the unfortunate Captain Tuckey, on the rocky banks of the Saire ; and by Sir Robert Schomburgk, at Berbice. On the Orinoco these leaden-colored rocks are supposed, when wet, to give forth noxious exhalations ; and their vicinity is believed to be conducive to the generation of fevers. It is also remarkable that the South American rivers generally, which have black waters, (*aguas negras*,) or waters of a coffee-brown or wine-yellow tint, do not darken the granite rocks ; that is to say, they do not act upon the stone in such a manner as to form, from its constituent parts, a black or leaden-colored crust.

[2] This engraving was not received in season to be inserted in Chapter VIII.

The polish of the pebbles, and the lustre of the blackened rocks, are doubtless due to a similar action of sand, or rather, of a much finer-grained sand and dust, driven to and fro by the winds, and not progressing in any one direction only, as in the gorge of the Pass.

A pebble of a stratified rock, in silicious layers, some harder than the others, found near the Alamo Well, was cut on all sides, so that the hardest layers stood out in relief. This specimen had evidently been cut while lying loosely on the surface, for the cutting had taken place on all sides alike. That its form was not due to solution of the softer parts by water was proved, not only by the hardness of the surface, but by the presence of little grooves, along which the sand had travelled, precisely as upon the rocks of San Gorgoño. Many of the specimens of silicified wood, found upon the surface of the Desert, are cut so deeply in grooves that it seems probable that they are less than half of their original size. The surfaces of such specimens are perfectly smooth, but are without that fine polish seen on the pebbles of the upper plain. The specimens which are exposed upon the open plain, where the wind is variable, and is constantly shifting the coarsest sand, are acted upon with much greater rapidity than on the upper plain, where it is believed the coarse sand has long since been chiefly removed by the prevailing north wind, leaving the pebbles to be acted on by the fine dust alone.

ELEVATION OF THE SURFACE—TERRACES.

No part of the Desert is much elevated above the level of the sea, and there is great reason to believe that most of the surface north of the emigrant road, from the Gila to the coast, is below it. It is below the level of the Colorado River, the stream having banks more elevated than the surface of the country a few miles back of it, as in the Mississippi and other rivers which carry down large quantities of silt and overflow their banks. That these conditions exist in that region is proved by the fact that the overflow from the Colorado extends inland for about sixty miles, and sometimes forms a deep and rapidly flowing stream. This establishes the fact of a great depression, but it was likewise shown by the barometrical observations on the portion of the Desert still further north, and beyond the known limits of the overflow from the river. Thus, at the Cohuilla Springs, November 18th, a depression of 81 to 99 feet below mid-tide was indicated; again, on the 20th, at the camp on Salt Creek, the mean of five observations shows a depression of 42 feet. At these stations it was evident that there was much lower ground beyond, nearer to the middle of the Desert. This became very evident when the plain was viewed from the base of the mountains on the west side, near the point of rocks, on which the water-line of the ancient lake was so distinctly seen.

From this point of view the ground appeared to slope off very gradually to the centre of the valley, about fifteen miles distant. The depression appeared to be as much as 500 feet. The extent of this depression, and the geological structure of that part of the Desert, is shown on Section 12, Sheet VIII. It is certain that this part of the Desert is lower than the banks of the Colorado. This is proved by the overflow of the river and the current to the interior along the extended channel of New River. The surface of the Desert, therefore, ascends, slope-like, towards the Colorado. This observation will probably apply to the alluvial deposits of the Desert only; the upper or pebbly plain of the Desert probably does not partake of the inclination, but remains nearly horizontal. It is probable, however, that on the northwestern margin of this plain it does not form a bluff or terrace, as along the course of the river and at Pilot Knob.

It is believed that it gradually breaks down into a slope and thus becomes merged in the general slope of the Desert.

In crossing the Desert, several banks or terraces are ascended and descended. One is found at the Alamo Well, and another at Cook's Well. It is impossible to decide whether these banks are continuous between the two points, or whether they mark the limits of two plains or terraces at different elevations. It is believed that they do, and that other and intermediate banks or terraces are found between the Colorado and the lowest part of the Desert. At the Colorado, only two terraces are found—the bottom-land and the upper plain covered with pebbles. But further inland the banks or terraces are very different, being formed of clay, and it is probable that an intermediate terrace is formed between the bottom-land and the upper plain. This indicates an increased difference of level between the bottom-land and the upper plain, a condition which must of necessity exist if the upper plain does not conform in its descent to the channel of New River. We may conclude, that on the Desert there are at least three terraces, or plains, marked by abrupt descents.

The first or lowest, borders the Colorado and forms its bank; the second, forms a bluff at Cook's Well and beyond, and the third is the high pebbly plain of the Desert. The first terrace is properly the river-bottom, and is subject to partial overflow. It is formed of a fine alluvial clay from the river, and is well wooded near the river with a growth of willows and cotton-wood trees. Near the head of the Gulf, this terrace, or possibly one at a lower level, is overflowed during the spring tides. It is traversed in many places by dry *arroyos* and is watered by New River, which holds a relation to it like that of the Colorado.

The second terrace is composed of an older alluvion, being entirely of clay, without sand or gravel. The extent and boundaries of this terrace are not accurately known. It forms a steep bank above Cook's Well, and may extend to the Alamo, where there is a similar bank. Its elevation probably diminishes towards the Colorado until it becomes merged in the first terrace near the Indian village, or Algodones. The trail follows this terrace, or plain, for a long distance, and the surface is wooded in some places by mezquite bushes. It is probable that the surface of this plain gradually descends towards the interior, conforming to the inclination of the first terrace.

The third terrace forms the highest plain of the Desert. Its margin is seen in the vertical banks which overhang the bottom-land of the Colorado and Gila. It also extends from Pilot Knob westward, and borders the north side of the road as far as a point about half way between Cook's Well and the Alamo. Its extent beyond this point is not known, but it is supposed to break down into a gradual slope to the level of the second terrace. The road is believed to ascend this slope between the Alamo and Cook's Well, and thus to be for a part of the way upon the upper plain. This denuded or broken part of the upper plain is not, however, like the surface around Pilot Knob and the Sand-Hills; it is without many pebbles, and is more sandy.

The probable extent of the third or upper plain is readily seen upon the map, it being colored as Post-Tertiary. I have also endeavored to represent the general character of these terraces, and their relation to the Sand-Hills, by a section from north to south between Cook's Well and the Alamo—Section 14, Sheet VIII.

All these terraces become merged into a continuous slope between the Alamo and the Big Lagoon. Thus, in passing from Carrizo Creek towards the Gila, the traveller, after descending to the level of the Lagoon, ascends by almost imperceptible degrees to the surface of the upper

plain. The abrupt terraces, therefore, exist only along the Colorado, and as far west as the narrow part of the alluvial clay formation, a few miles west of the Alamo.

It appears from the observations of Mr. Charles H. Poole, of the United States land survey, that the surface of the Desert, northerly from the Big Lagoon, is a gradual slope, and that a very considerable depression exists in that direction. This slope appears to extend from the low ground to the level of the upper plain, without any break corresponding to the terraces that have been described. Mr. Poole also states that a distinct *beach-line* extends along this slope, and marks the shore of a former sheet of water.

The dry arroyo, or canal-like water-course, which was found between the lagoons, is in all probability the channel of New River. This stream derives its supply from the Colorado only at times of high water, and it is probably fed through numerous and ramified channels of slight depth. The precise locality of the entrance to the stream is not known; this renders it more probable that there is not a well defined channel at the Colorado, but that the water spreads over the banks and afterwards collects into one channel.

GEOLOGICAL FORMATIONS.

The geological structure of the Desert is very simple. The bluish clay is of alluvial or lacustrine origin, and the gravelly plains or low hills around the bases of the mountains are Tertiary or Post-Tertiary. The only other formations known are the granitic and metamorphic rocks of the mountains on each side, with erupted dykes here and there.

The metamorphic rocks of the mountains on the western side of the Desert have already been sufficiently described in the Itinerary. Nearly all the points of rock that we passed were highly laminated, and contained lenticular beds of limestone. The peculiar angular character of most of the outcrops is well exhibited by View XIII. In this instance the rocks rise above the level surface of the alluvium or clay of the Desert. The point of rocks forming the end of one of the long and high ranges extending on the northeastern side of the Desert is also metamorphic, if the structure of the rock is regarded as good evidence of it. It is laminated and gneissoidal. The relative position of the ridges, their parallelism, and overlapping one beyond another, is regarded as indicative of their stratified origin and subsequent plication. The outcrop at Pilot Knob is very probably a continuation of one of these ridges, or the summit of another, in great part buried by the Tertiary of the Desert. At Fort Yuma the rock is eruptive, or so far metamorphosed as to lose all traces of a sedimentary origin. It is a dense porphyritic granite. The ranges extending from the Gila southeasterly through Sonora are properly a prolongation of the chain bounding the Desert on the northeast, and, without doubt, present a a similar geological structure. This chain is very much broken, and partakes of the character of the short, overlapping ridges of the Great Basin.

Of the sedimentary and recent formations of the Desert, the alluvium has by far the greatest extent of surface, and is connected with the bottom-land of the Colorado. It, in fact, may be said to extend from the borders of the stream and the head of the Gulf for about 170 miles northwest to the base of the Bernardino Pass. Where first seen—at the Deep Well on the southeastern side of San Gorgoño mountain—it was a fine blue clay, mingled with sand, and it had nearly the same appearance and composition in all of the ravines that were crossed in the transit from the Pass to Carrizo Creek. In some places a part of the clay was observed to have a reddish color, and this was particularly the case at the Alamo Well. The clay at the Deep Well was more sandy than at other localities, it generally being very fine and indurated, so that it could

METAMORPHIC ROCKS — BORDERS OF THE [illegible]

be broken out in blocks. The lines of stratification were very numerous and horizontal; this, with the absence of coarse materials, indicating that the water from which it was deposited was comparatively quiet. The fossils found in this clay, at different points over a distance of nearly one hundred miles, show the lacustrine origin of the greater part of it. All the shells that were collected were submitted to Dr. Augustus A. Gould, of Boston, for examination, and his descriptions accompany this report. He finds them to consist of the following species, four of them being new: *Gnathodon Lecontei*, Conrad; *Planorbis ammon*, *Physa humerosa*, *Amnicola protea*, and *Amnicola longinqua*.[1] In addition to these, *Anodonta Californiensis*, Lea, was very abundant, especially in the northern part of the Desert. These show the deposit to be of fresh-water origin; the *Gnathodon*, however, is a brakish water genus, and is found in the mud of estuaries. This shell was not seen in the northern part of the Desert, where the others were most abundant, but was procured for the first time near Salt Creek, about twenty miles north of the entrance to Carrizo Creek.

The Tertiary is also characterized by the fossils obtained at Carrizo Creek. These are found by Mr. Conrad to be new species of *Ostrea*, *Pecten*, and *Anomia*, and he has named them as follows: *Ostrea vespertina*, *O. Heermani*, *Anomia subcostata*, *Pecten Deserti*.[2]—(See Appendix, Article II, and Plate V, figs. 36, 37, 38, fig. 34, and fig. 41.) They are believed to be of the age of the Miocene. These were the only fossils found in the strata around the Desert. There is little doubt that the strata containing such vast numbers of concretions outcroping north of Salt Creek, and those seen between the Hot Spring and the base of the Pass of San Bernardino, together with those forming the bank or terrace between Pilot Knob and Fort Yuma, are of similar age. The horizontal beds around Pilot Knob, bearing the stratum of conglomerate at the summit, are much more sandy and modern in their appearance than the fossiliferous series of Carrizo Creek, and it is very probable that they are more recent, and superimposed upon the Miocene strata. There is little doubt that the Miocene underlies the alluvium of the Desert, and it will probably be found along the base of the mountains on the northeast side in outcrops similar to those on the west.

ANCIENT LAKE.

The former existence of an extensive fresh-water lake in the northern part of the Desert is shown not only by the extended deposit of alluvial or lacustrine clay, containing fossils, but by the existence of extended shore-lines and beaches along the sides of the bordering mountains. The great depression of the surface below the level of the Colorado, and probably below the level of the Gulf, shows also the probability that the region was once submerged. The extent of this submergence, or the limits of the former sheet of water, is now indicated to us by the fine clay which must have subsided from it. The extent of this clay is shown upon the map. In the northern part of the Desert it is seen to reach nearly from one side of the valley to the other, while on the southeast it reaches to the head of the California Gulf. There is no barrier in that direction, and it is impossible to resist the conviction that the waters of the Gulf once occupied the whole space, and extended up to the base of the San Bernardino Mountain. The valley of the Desert is, in fact, but the northern end of the great valley occupied by the Gulf, and the probability that it was once submerged is exceedingly strong. When, however, we consider the fact of the former existence of a great lake, and the peculiar configuration of the valley and its relation to the Colorado River, it becomes almost certain that the waters of the Gulf did cover the region, extending nearly one hundred and seventy miles further inland. Thus, if the

[1] See Plate XI and Appendix, Article III.

[2] Descriptions of these were published in connexion with the Preliminary Report, H. Doc. 129, 1855.

alluvial deposits of the Colorado River were removed, it is probable that the Gulf would extend as far north as the base of San Gorgoño and San Bernardino. Under the supposition that in this way the Gulf formed a long, narrow bay, reaching far above the mouth of the Colorado, the retrocession of the water and the formation of a great lake is readily explained.

The raised banks of the Colorado show the vast amount of sediment that has accumulated along its course, and that has been discharged into the Gulf. The clay of the northwestern part of the Desert is similar in its character to that forming these banks, and it must be regarded as derived from the same source. It is probable that only the heavier and coarser materials were deposited near the stream, and by their accumulation displaced the waters of the Gulf, and formed a broad delta. The encroachment of this delta, and its final extension to the opposite shore, was sufficient to shut off the waters of the upper end of the Gulf, leaving them in the condition of a lake, connected with the river and the Gulf by a narrow channel or slough. The peculiar configuration of the valley was highly favorable to such a result. The waters of the Gulf formed a long and narrow bay, extending one hundred and seventy miles inland, northwest of its present limits; the Colorado entered at its narrowest part, one hundred and forty miles below its upper extremity, and below its most contracted part; the current came in at right angles to its general direction, and thus the suspended alluvion was spread out in the waters at the point where the division of the Gulf could be most rapidly effected, and under circumstances favorable for its subsidence. Under these conditions, the channel connecting the upper and lower portions of the Gulf, must have gradually become more and more shallow, and the continued growth of the delta must have filled it up, so that the tide could no longer ebb and flow to the upper end, thus forming a lake, its only barrier on the south being the silt and mud of the Colorado. This barrier was probably an extended flat, and not a narrow bar, for the silt was undoubtedly much spread about by the tides, and the current caused by the influx of the river. A very considerable portion of the silt was doubtless carried to the extreme northern part of the Gulf, forming the foundation for the superstratum of clay of lacustrine origin which we now find there. The accumulation, however, was undoubtedly most rapid and deep opposite the mouth of the river, and it must have formed an effectual barrier between one part of the Gulf and the other. It must have been covered by only a few feet of water, and was thus left entirely bare at low tides. Such conditions were most favorable for the rapid growth and transformation of the flats to dry land or salt marsh. Every great freshet in the stream must have made great additions to it, until at length it was submerged only when the tides were very high, and the river was much swollen. In that climate, a surface of mud exposed to the sun and air, and so well watered, must have been covered with a luxuriant growth of tule, grass, and other vegetation; and it doubtless existed for a long time as a low swamp, traversed in every direction by sloughs and channels.

It is probable that even after the delta had so far grown as to be above the water, there were numerous, narrow, canal-like channels between the river and the lake, or between the lake and the Gulf; so that the water in the lake was constantly retained at the same level. That the lake received its supply of water, in great part, from the river, is shown by the fact that it was *fresh-water*, or but slightly saline; the presence of salt or brackish water being proved by the fossil shell *Gnathodon Lecontei*. The great deposition of clay containing the shells probably took place in this way; the current of the river being at times, if not constantly, turned in that direction. In this case the excess of water, if not removed by evaporation, must have flowed out into the Gulf by some channel further south. It is not impossible that the Colorado once

flowed along the line of banks or terraces near Cook's Well and the Alamo, and after depositing its silt in the quiet water of the lake, escaped into the Gulf, at some point near or below the present entrances to New River. With the immense quantities of silt that the Colorado brings down, even now, such conditions could not long remain, and the river must have been turned towards the more open wáters of the Gulf by the resistance of its own depositions. After the lake had become deprived of its supply of water from the river, and its communication with the Gulf became closed, except, perhaps, at seasons of freshets, it must have undergone rapid evaporation, especially in that region of violent, arid winds, pouring in from the surrounding deserts and over the mountains from the sea. The great rapidity of evaporation in the climate of the Tulare Valley has been shown, and it is not difficult to comprehend that this cause was sufficient to remove all the water from the lake in the course of a few years.

Some of the conditions which have been detailed as probable are still found to exist. The Colorado yet continues to overflow at seasons of high water, and the water runs backward for sixty miles, and forms a chain of small lakes or ponds; the water in these evaporates rapidly, and disappears soon after the supply ceases. We find an extensive area of low and marshy land around the head of the Gulf, which is annually overflowed and covered by quantities of silt spread out upon it by the Colorado. Father Consag, who made the first survey of the Gulf in 1746, ascending as far as the mouth of the Colorado, describes the land about it as low and marshy; the mud being red, and so soft that it would not support the men when they stepped out upon it.[1] The enormous quantities of silt carried down by the river is shown not only by the dark-red color of its water, but by the discoloration that it produces in the water of the Gulf, which was formerly called the *Vermillion Sea*, probably from its red color.

Changes very similar to this displacement of the waters of the Gulf and the formation of a lake have taken place in other parts of the world, and it is not at all surprising that the deposition of sediment by the Colorado should produce the results which have been effected, when we consider the enormous amount of silt brought down by the Mississippi, the Nile, Ganges, and other rivers, and the rapid increase of their deltas. According to the observations of W. K. Loftus,[2] the head of the Persian Gulf, within a comparatively recent period, extended, certainly, two hundred and fifty miles further to the northwest than the present mouth of the combined stream of the Tigris and Euphrates, and one hundred and fifty miles beyond the junction of these two great rivers at Korna. The alluvial deposit from these rivers is said to increase a mile in thirty years;[3] and Sir Charles Lyell gives a statement, made by Colonel Rawlinson, that the delta of those rivers has advanced two miles in the last sixty years, and is supposed to have encroached about forty miles upon the Gulf of Persia in the course of the last twenty-five centuries.[4] Very great changes have also been produced at the mouths of the rivers which enter the Adriatic Sea. It is stated by Lyell that "there is an uninterrupted series of recent accessions of land more than one hundred miles in length, which, within the last two thousand years, have increased from two to twenty miles in breadth."[5] If these great accessions of land had been confined to the mouth of one stream many miles below the head of a narrow gulf, a lake would most certainly have resulted. If the Colorado had emptied into the head of the Valley of the Gulf in the same manner as the Tigris and the Euphrates enter the Persian Gulf,

[1] Father Fernando Consag, in Venega's History of California, ii., p 144.
[2] Quarterly Journal of the Geological Society of London, xi., 43, p. 251.
[3] Ainsworth and Rawlinson, Proceedings Geographical Society, 1850.
[4] Lyell's Principles of Geology, p. 285.
[5] Principles, p. 256.

results similar to those at the mouths of those rivers would, undoubtedly, have been produced; the sea would have been displaced, and a broad delta would have been formed, traversed by many channels.

The explanation of the formation of the lake, and its disappearance, by evaporation, which has been presented, agrees with the traditions of the Indians. Their statement, that the waters retired little by little, is consistent with the gradual subsidence due to evaporation; and the sudden floods, of which they speak, undoubtedly took place. It is probable that the lake was long subject to great floods, produced either by overflows of the river at seasons of freshets, or by a change in its channel, or by a great freshet, combined with a very high tide, so that the river became, as it were, dammed up and raised to an unusual height. The present overflows, though but very slight, are probably similar; and yet it is possible that the interior of the Desert might be deluged at the present day, provided no elevation of the land has taken place, and the river should remain at a great height for a long time—long enough to cause the excavation of a deep channel for New River.

Many more facts and observations are required before a full explanation can be given of the progressive changes that have taken place during the formation of the delta and Ancient Lake. We need to know the actual level of different parts of the surface of the Desert, and an exploration of the terraces and channels between the Alamo and the head of the Gulf is desirable.

The foregoing observations on the origin or formation of the Ancient Lake have been made without regard to the possibility of a change of level of the whole or a part of that region. It is very possible, and even probable, that there have been such changes. A slight elevation of the delta would have had the effect to deepen the channel of the river, and in this way would have hastened the isolation of the lake. There certainly has not been an elevation of the region sufficient to drain the lake, for the flow of New River shows us that the surface remains lower than the Colorado. A slight elevation of the whole region would probably have merely hastened the changes which have been described. If the precise elevation of the water-line, which remains so beautifully distinct on the sides of the mountains, could be ascertained, it would show at once whether there has been a change of level. The importance of determining its altitude for this object led me to make the attempt by the barometer; but there not having been simultaneous observations at the sea-level nearer than Benicia, over five hundred miles distant, the result cannot be regarded as conclusive. The height of the mercury was found to be 30.248 inches; attached thermometer, 76°; detached, 76°. The comparison of this observation with the stationary barometer at Benicia, gives, as the altitude of the station, forty-six feet above mid-tide. The addition of one hundred feet, the estimated height of the water-line above the barometer, gives us as its elevation *one hundred and forty-six feet*. The result shows conclusively that the water-line is not far above the sea-level; but it is believed that the possible errors consequent upon the distance, and diverse local influences of the two barometers, may be greater than the altitude indicated. The water-line *may*, therefore, be at the sea-level; its exact altitude cannot be ascertained without simultaneous observations at the shore of the Gulf, or by leveling. It is also very possible that the rough estimate of the elevation of the water-line above the barometer station is as much as forty or forty-five feet too low or too high; and this error, if too high, combined with one of one hundred feet in the barometrical indications, would place the line about at the sea-level. If, however, the line is elevated as much as one hundred and fifty feet, there is still a wide area in the central part of the Desert which must be below the sea. The probability of a slight elevation is rendered greater by the fact

that the coast at San Pedro, and along the Santa Barbara channel, has undergone a comparatively recent elevation of about thirty feet, as shown by fossils in the banks. This elevation may have been independent of the region at the head of the Gulf, but it is more probable that it was not. A powerful cause for an elevation, sufficient to hasten the changes which have taken place, is indicated to us by the earthquake disturbances which are so common in that region. The earthquake of 1852 was sufficiently violent to break off a portion of Chimney Peak, and to open fissures in the clay of the Desert. Such agitations can scarcely fail to affect the level of parts of the delta or to modify the course of the river.

The water of the Ancient Lake was remarkable for the great amount of carbonate of lime which it held in solution and deposited on its shores. The calcareous water does not, however, appear to have been confined to the limits of the lake, for thick deposits of calcareous sinter or travertin were found in the crevices in the granitic and metamorphic rocks of Pilot Knob, and in the stratum of conglomerate forming the upper plain of the Desert. Near Pilot Knob, this conglomerate was formed of pebbles imbedded in a calcareous paste, which filled all the interstices, so that a mass of the rock looked like pebbles imbedded in mortar. The stones could be detached, but left cavities or casts of their forms. The stones or boulders found on the slopes of the Desert, below the water-line, were also invested with a calcareous crust. These facts all show the prevalence of calcareous water over that region in former times. The deposits of Pilot Knob, and in the bank of conglomerate forming the broad upper plain, may at first be regarded as an indication that the water of the Ancient Lake extended over them, or that it was not confined to the long, narrow valley of the Gulf, but spread out over a broad surface along the Colorado and Gila, far above their point of confluence. Whether this was so, can only be determined by measurements of the altitudes of the plain and water-line. The water, if thus extended, could not, however, have been a lake, for there is no barrier between the upper plain and the Gulf. It is probable, therefore, that the calcareous deposits of the Ancient Lake, and those of Pilot Knob and the conglomerate, are entirely distinct and of different age.

There is much variation in the thickness of the travertin at different parts of the shore of the lake. At the point where it was first observed, in the northern part of the Desert near Deep Well, its thickness was not over four or five inches ; it was also less compact and hard than that afterwards seen. At the next point where the elevation was taken, it was nearly two feet thick, covering the rocks completely, so that all the edges and angles were rounded off. This deposit was extremely hard, and yet filled with long tubular cavities, opening upon the surface, so as to give it an appearance similar to a coarse coral. Small shells, of the same species as those found in the clay, were enveloped in the mass of this crust at least six inches below its surface ; they may occur at a greater depth but were not observed. The outer part of the deposit, if not the whole, was thus formed by the lake while the water was fresh or only slightly brackish.

This great quantity of carbonate of lime, once diffused in the water of the lake, was probably supplied by springs, either at the bottom of the lake or near its borders. This is rendered more than probable by the existence of a group of springs in the valley of the Desert, with the water highly charged with carbonic acid, and surrounded by conical mounds which are probably calcareous sinter. The quantity of water and carbonate of lime which they formerly delivered may have been much greater than the present supply. The springs of San Felipe Creek may, also, have furnished a great quantity of the calcareous water, for they are still depositing travertin, and a thick layer is found on all the rocks of the ravine. In some places the thickness

is not less than three feet, and it is so abundant as to line the whole bed of the stream, hiding all the rocks from view. Portions of the mass were traversed with long cylindrical tubes; they being the casts of reeds and rushes similar to those now growing in the water. This stream runs towards the valley of the Ancient Lake, and at certain seasons of the year may deliver a large quantity of water. It serves as an indication of the source of the calcareous water of the former lake, and there are doubtless many other streams of a similar character in that vicinity.

It is singular that the name of this valley is already associated with calcareous springs in Europe. The springs and baths of San Fillipo, in Italy, are famous for the quantity of lime contained in the waters and for the manufacture of medallions by its deposition. The water which supplies the baths falls into a pond, where it has been known to deposit a solid mass thirty feet thick in about twenty years.[1] It is also stated that "a hard stratum of stone, about a foot in thickness, is obtained from the waters of San Fillipo in four months; and as the springs are powerful, and almost uniform in the quantity given out, we are at no loss to comprehend the magnitude of the mass which descends the hill, which is a mile and a quarter in length and the third of a mile in breadth, in some places attaining a thickness of 250 feet at least." "A large proportion of the most splendid edifices of ancient and modern Rome are built of travertin, derived from the quarries of Ponte Lucano, where there has evidently been a lake at a remote period."[2]

The calcareous deposits on the shores of the Ancient Lake are not crystalline or stalactitic, nor do they exhibit distinct layers or successive coats, as is the case where the deposition proceeds under full exposure to the air, and the water flows over the surface slowly, or in a thin layer. On the contrary, the deposition appears to have been rapid, and below the surface of quiet water.

The sinter of Pilot Knob is less compact than that marking the shore of the lake, and does not appear on the surface of the rocks, being confined entirely to the clefts and crevices, as if it had originated there instead of being deposited from without. This was very possibly the case. The fissures may have given passage to the calcareous water from below. The specimen which was collected has been analyzed for me by Dr. J. D. Easter with the following result:

Insoluble residue (silica)	8. 629
Carbonate of lime	85. 70
Sulphate of lime	0. 246
Carbonate of magnesia	0. 449
Peroxide of iron	1. 11
Alumina	2. 085
Silicate of soda	0. 847
Chloride of sodium	0. 346
Phosphoric acid	trace.
	99. 412

Further observations on it will be found in the Appendix, Article VII, Specimen 250.

THE SAND-HILLS.

The sand of the Colorado Desert forms, as has been shown, but a small part of its surface. It is not found in a broad and thin layer, but is gathered together by the wind into heaps and drifts, serving to break the monotony of the level plain. These hills are remarkable for the

[1] Dr. Grosse on the Baths of San Fillipo. Ed. Phil. Journal, ii, p. 292.

[2] Sir Charles Lyell, Principles of Geology, p. 242–243.

beauty of their wave-like outlines and the purity of the sand. It is free from fine, earthy dust, and being perfectly dry moves about before the wind like the dry sand that has been washed on an ocean beach. The color varies somewhat at different localities, but is generally a light buff or reddish yellow, similar to ordinary river sand. A large proportion of the grains are translucent, and some are transparent; many are dark-red and appear to be carnelian; others are black, green, and brown. The clear grains are mostly silicious, and the others are probably derived from the wearing of volcanic rocks. Small garnets are not uncommon, and in some places considerable black iron-sand is found. When the sand is mixed with water, and treated with hydrochloric acid, a brisk effervescence ensues, indicating the presence of a notable quantity of carbonate of lime.

The grains present an interesting appearance when viewed with a microscope. All the little asperities and sharp edges are seen to be worn away, and their surfaces are rounded by attrition, so that many of the grains are perfect spheres. It is not difficult to find quantities of the spherical grains by bringing the eye closely to the surface of the ground, especially where gravel is abundant, as in such places the grains are much larger than on the sand-hills. I thus obtained a great variety of little polished spheres of quartz, agate, garnet, and a transparent green mineral, probably chrysolite. The color of the sand at Deep Well is a little darker than that between Carrizo Creek and the Colorado, and is not quite so fine.

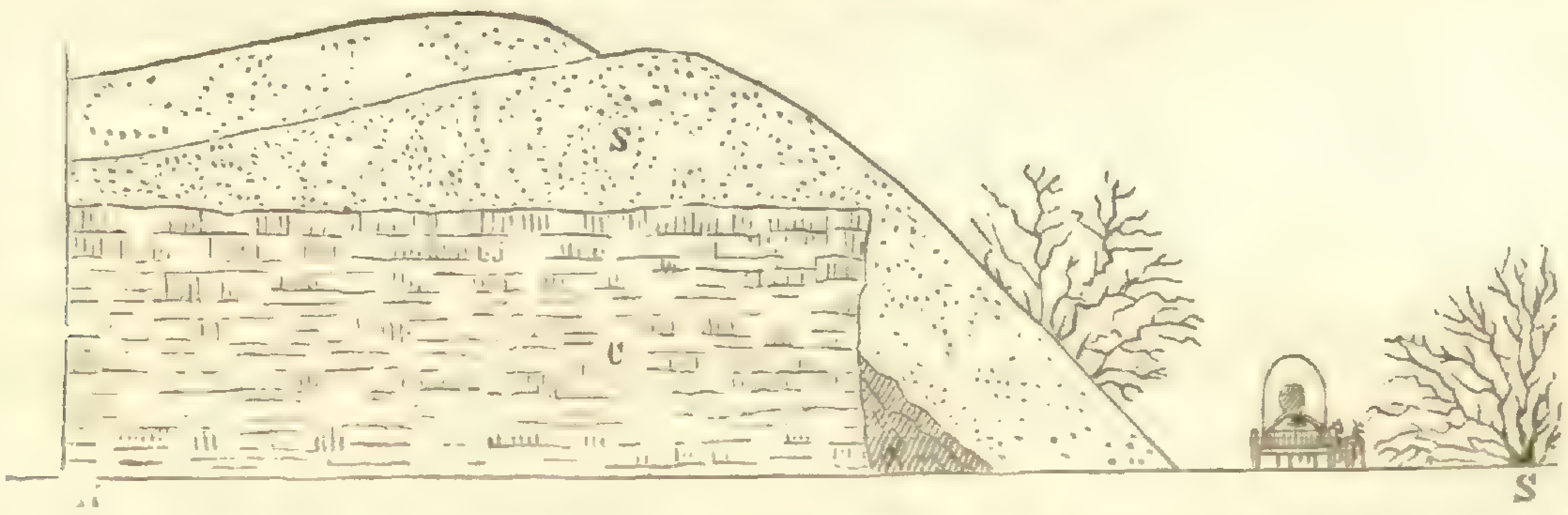
The principal accumulations of the sand are at the following localities: Between Pilot Knob and Alamo Mocho; between Carrizo Creek and Salt Creek; at Deep Well; in the Bernardino Pass; and on the north side of the Desert, opposite Deep Well.

The position of the principal of these accumulations will be found upon the geological map of the Desert, where they are indicated by the finely dotted spaces.

The most formidable and extensive accumulation is that between Pilot Knob and the Alamo. This constitutes what has been known as the "Sand-hills of the Desert;" the other localities being either insignificant, or being in unexplored places. This accumulation of sand-hills borders the emigrant road on the north side for several miles; it is a part of a long crescent-shaped belt of sand, that extends from Pilot Knob to the vicinity of the Alamo.

In passing from the Colorado towards the Pacific, the first sand-hills of this belt are seen at the Indian village, overlying the upper terrace. Nearer Cooke's Well the sand has poured over the bank, as shown in the figure, so that it encroaches upon the road, and partially buries

SECTION OF SAND-HILLS COVERING THE BANK.



S, Sand, drifting from the north; *C*, Clay and sand of the bank or terrace.

some of the mezquite bushes. Beyond Cooke's Well the sand falls over the terrace in a similar manner. In fact, the southern extent and range of the sand-hills of this belt is determined by, and coincides with, the bank or terrace constituting the margin of the upper or higher plain of the Desert.

It is from the surface of this gravelly plain that the sand is derived; it is swept from it by the strong winds, and travels along until the force of the wind is broken or changed by some natural obstacle. At such places the sand is dropped, and soon becomes heaped up into undulating ridges, which simulate the billows of the ocean by their wave-like contour. All the principal sand-hills appear to have accumulated upon the edge of this terrace; and they do not extend beyond it. Those near the road, between Cooke's Well and the Alamo, do not exceed sixty feet in height, and this is much greater than the average elevation. From the tops of these there are, however, other hills visible, two or three miles eastward, which appear much higher, and may be over one hundred feet high.

I ascended the hills at a point a short distance from the Mezquite Well, and crossed over among them to their northern limits. At that place the width of the belt was less than half a mile. It is, however, wider further to the east, but probably does not exceed one mile at the widest part. The hills are highest near the bank, and gradually thin down into a gentle slope towards the north. The outline of a section of the belt, from north to south, may be illustrated by the figure; the direction of the wind and the progress of the sand being shown by the arrow.

SECTION OF THE SAND-HILLS.

The wave-like outline of the hills is apparent, and it will also be noticed that the windward slopes are long and gentle, compared with those turned from the wind. The latter are abrupt, and are generally inclined at an angle of thirty degrees, being as steep as dry sand will lie. The relation of the sand-hills to the terraces is illustrated by a short section. * (See Sheet VIII.)

When one penetrates among these round sand-hills, so that every other object is shut out from view, they seem like gigantic snow-drifts; and the low, rustling sound, produced by the moving sand-grains, is very similar to that made by hard, dry snow, when driven before a high wind. The sand does not rise high in the air, but bounds along on the surface, or only a few inches above it, so that the drift is enveloped in a sheet or atmosphere of moving grains. They gradually rise the slope, and when they reach the highest point, they fall down the steep bank to the leeward.

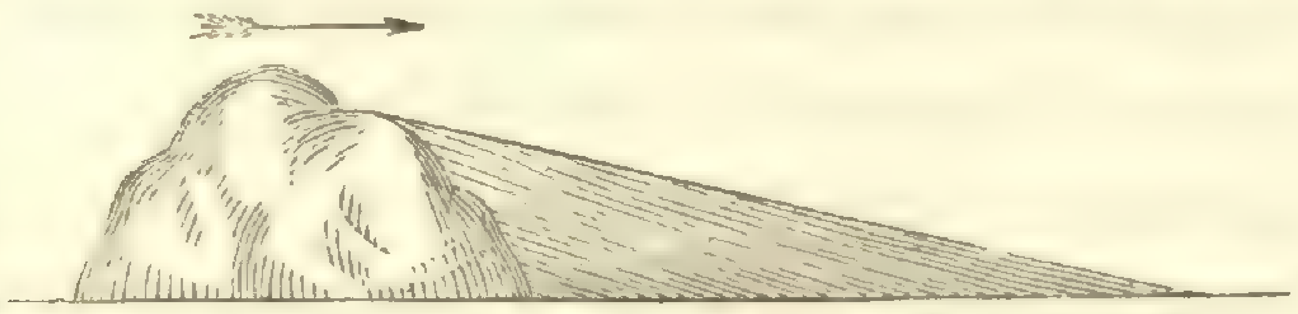
All these drifts and hills are covered with the most perfectly formed little waves and furrows, corresponding with the ripple-marks produced by water. These *air* ripple-marks are, however, more perfect and regular than those made by water, and they extend over large surfaces.

The sand that has driven over the bank, along the road, has so covered the terrace from view, that it is generally supposed that the hills are formed entirely of sand; the fact that the sand is merely a coating or covering to the terrace has not been recognized. It is, however, clearly the case, for at many places the larrea is seen growing up through the sand, twenty feet above the road. This could not be without a foundation for the roots more firm than is furnished by the bare sand.

There are but one or two points, in the whole distance between the Colorado and the Alamo Well, where the sand-hills present a formidable appearance; or it seems possible that they can encroach on the road so as to render it impassable. The progress of the sand appears to be stopped by the vegetation, (*Larrea Mexicana* and mezquite,) and by the natural receptacle formed by the steep bank over which it falls. This bank acts as a complete bar to the further progress of the sand. It is more perfect in this respect than a wall-like barrier could be, for all the sand

that pours over its edge is protected from the further action of the wind, which is allowed to preserve its general direction, and passes on without being thrown into violent eddies, as would be the case if its progress was impeded by a wall, or any prominent object.

The movements of the sand in the air are precisely similar to those that take place when it is immersed in the more dense fluid, water. The progress of the grains along the surface of the plain, and their final rest at the edge of the bank, is precisely similar to the transportation of sand by a stream, and its deposition, in the form of a bank, whenever the current enters deep water. In water, little eddies and back currents are produced by a projecting rock, or root, acting as a barrier to the current, and drift-sand accumulates on the lower side of such obstacles. So, in air, wherever a slight obstacle, such as a bush, or boulder, stands on the plain, exposed to the wind, the driving-sand accumulates on the lee side, as in the figure.



DEPOSITION OF SAND ON THE LEE SIDE OF OBSTACLES.

We have thus considered the phenomena, and the mode of progress of the principal sand-hills of the Desert, and the conclusions to which we may arrive may be stated as follows:

1. The sand is derived from the surface of the upper gravelly plain of the Desert by the continued action of the northerly winds.

2. These sands have accumulated along the margin of this plain, and form a belt less than a mile in width, and about twenty miles in length.

3. The hills seldom reach a height of sixty feet; and most of the high hills, heretofore supposed to be composed entirely of sand, are underlaid by a high bank of clay and gravel, and the sand is a mere covering.

4. That the terrace, forming the margin of the plain on which the sand rests, acts as an effectual bar to its further progress.

In view of these facts, I see no reason to regard the Sand-Hills as a serious obstacle to the construction of a railroad. They occupy so small a part of the wide area of the Desert, that, if necessary, they can be avoided. The road could be safely built on the hard clay surface of the first or second terrace, carrying it several miles south of the sand; or, if it is desirable to run in a more direct line, from the Gila to the Pass of San Bernardino, the road can be made on the upper plain, far in the rear of the sand, and on its windward side. It is not necessary to carry the road *across* the Sand-Hill range. The hills have a direction that would be nearly parallel to the course of a road.

There is a thin layer of sand on the bank above the Alamo Well, but it does not form a drift or hill of such a magnitude as to render it worthy of particular notice. Sand is again met in similar thin sheets, varying from three inches to a foot in depth, in the vicinity of the Lagoon. It fills up the little crevices and little irregularities in the surface of the clay, and is readily shifted about by the winds. Several drifts were also passed between the emigrant trail and the Salt Creek. They are long and narrow, and do not present any formidable appearance; they are not deep; and the wagons of the train crossed them without much difficulty. They form long and narrow strips or belts of sand, which are only a few inches deep for the greater part of their extent; but in one or two of the highest points, their depth may be ten feet. At Deep Well the sand is piled up into a range of low hills, not over twenty-five feet in height. They

are on the north side of the well, and several hundred yards north of the rocks forming the base of San Gorgoño Mountain, so that a smooth and unobstructed passage-way is left between them and the rocks. This accumulation has a length of three or four miles, and extends in a nearly northwest and southeast direction. The range has a width of at least one quarter of a mile, near the Deep Well; but its northern margin was not seen. This sand is not so fine as that between the Alamo and the Colorado; it, however, appears to have a similar chemical constitution.

The observations already made on the contour and the movements of the sand-hills east of Alamo Well will apply to these drifts also; but the circumstances under which they exist are quite different, in consequence of the absence of the terrace. The proximity of the bordering range of granite seems to exert an influence on the distribution of the sand at the well. It is probable that the violent lateral eddies, that are produced where the wind impinges upon the rocks, are sufficient to prevent the accumulation of the grains at the immediate base of the mountain. Appearances led me to conclude that an effect of this kind was produced; the fact that the sand is always thrown to the lee side of an obstacle lends additional support to the conclusion.

An immense body of sand has accumulated at the base of the mountains, on the north side of the Desert, nearly opposite Deep Well. It forms smooth, rounded hills, with wave-like surfaces. This accumulation is nearly opposite the slope of the Bernardino Pass, and is in the range of the strong, prevailing wind, which appears to be deflected back into the valley when it strikes the opposite mountains.

This body of sand is many miles north of the direct line between the Pass and the Gila, and cannot interfere with a railroad. Sand has accumulated at several points between the base and the summit of the Bernardino Pass. It, however, does not remain in the open spaces, but is confined to the projecting spurs of the granite of San Gorgoño. In these places it is always thrown to their leeward sides; and scarcely any is to be found on the side where the wind acts with its full force.

All the principal accumulations of sand on the desert, that are in the vicinity of the travelled route, have thus been considered in succession. It is evident that the sand forms but a small part of the surface of the Desert, and that it does not form a deep, wide-spread, and continuous layer; but that it exists in isolated patches and drifts, bearing but a small ratio in their surface to the areas from which they have been swept. The sand-drifts are so limited in their area, and are separated by such wide intervals, that the transit from the Colorado to San Bernardino may be made without crossing one of them. A railroad track can also be laid down between these two places without coming in contact with a single sand-hill.

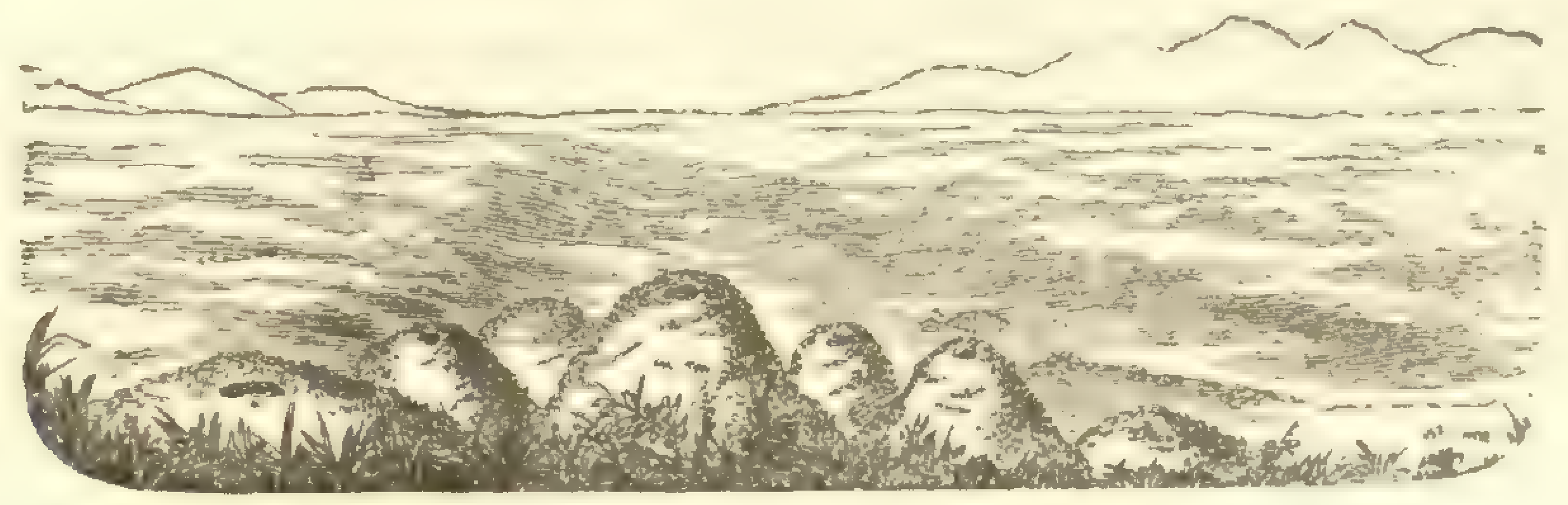
SPRINGS, WELLS AND STREAMS OF THE DESERT.—ARTESIAN WELLS.

On that portion of the Desert which is usually traversed by travellers and the emigrants to California, by the way of the valley of the Gila, and from Sonora, the main dependence for water is upon New River and its sloughs, and the two ponds—the Big and Little lagoons—which are, in fact, but portions of New River at times of high water. The wells of the Desert are on a side road to the northward of New River, and are not relied on by emigrants and travellers accompanied by many animals, or by droves of cattle. New River and its lagoons cannot be relied upon as an unfailing source of water; it depends upon the Colorado being filled during the

season of floods only, and not then unless the river attains an unusual height. It is frequently, and perhaps generally, the case that the annual freshet subsides without filling the channel.

The wells, if such they may be called, along the trail from the Colorado to Carrizo Creek, have already been described in the Itinerary. They exist chiefly in *name*, and require little description ; their condition at the time of my observations was abominable. Cooke's Well was a muddy hole in the clay, to which the mules and animals of travellers had free access, and it was prevented from becoming a mere mud-puddle only by a few short boards surrounding the water. The water, consequently, was always muddy, and there was but a small supply in the pool. The Mezquite Well was in a similar condition, but could be considered as in better order, a barrel having been placed in it. The Alamo Well is about eighteen feet deep, and is planked and curbed. The pressure of the moist clay at the sides had, however, pressed the planks inwards, so that they were in danger of giving way, and permitting the well to become closed. The lining of the well was secured by cross strips of plank, which were insufficient, and should be replaced by strong timbers, arranged as in the shaft of a mine.

Several other wells or holes in the clay have been excavated along the road, but at the time we passed they were filled up by the caving in of the banks, or by sand, so that they were useless. There is, however, a well between the Big Lagoon and Carrizo Creek which was not visited by the Expedition, but is said to contain water. It is known as "Sackett's Well," and its position is indicated on the map. The operations of the United States Land Survey have brought to light two new localities of water in the central part of the Desert. One is an Indian well, dug in an arroyo, of New River, probably, about eight miles north of Big Lagoon. The second is a group of springs, of highly carbonated water, directly west of Salt Creek. According to Mr. Charles H. Poole, who discovered them, they furnish a large supply of water of a very agreeable taste. The water boils up in several places, and has formed conical hillocks of earth about the openings, as shown in the sketch by Mr. Poole.



SODA SPRINGS, COLORADO DESERT.

The little hillocks vary from three or four to six and eight feet in height, and their sides are covered with grass. The water is found in the centre of these mounds ; and it is kept in constant motion by the escape of large quantities of gas, with which it is so highly charged that it was difficult to keep the corks in bottles that were filled with it. This gas was, without doubt, carbonic acid. The water, in its taste and effervescence, resembles soda water so closely that Mr. Poole gave the appropriate name of *Soda Springs* to the locality. They are about sixty miles distant, from the Colorado River, in a direct line, from the mouth of the Gila.

The existence of an extensive lagoon, or dry lake-bed, covered with salt, in the northern and lowest part of the Desert, is reported, but its precise locality is not known. The Indians are accustomed to resort to it for salt, which they say is found there in large quantities. It is said that this lake is sometimes flooded with water ; and it is possible that it is supplied by New

River, after the stream leaves Big Lagoon. Its position is indicated on the map as nearly as possible.

The northwestern side of the Desert, north of Carrizo Creek, has several springs at wide intervals, already described in detail in the Itinerary. The most interesting localities are the Hot Spring and Deep Well. Deep Well is interesting as the first locality of water on the Desert south of the San Bernardino Pass, and for its peculiar construction by the Indians. The water is approached by steps as in the East.

The following table includes all the known localities of water, with the exception of New River, on the line of the trail between the Colorado, at the mouth of the Gila, and the Pass of San Bernardino. The distances from the Colorado are given in the first column, and the intermediate distances in the second:

	Distance from the Colorado.	Intermediate distance.
Cooke's Well	14.90	14.90
Mezquite Well	18.90	4.00
Alamo Well	36.20	17.30
Little Lagoon	51.95	15.75
Big Lagoon	62.24	10.29
Sackett's Well	73.24	11.00
Salt Creek	93.24	20.00
Water at Point of Rocks	118.24	25.00
Cohuilla Springs	130.80	12.60
Deep Well	146.62	15.82
Hot Spring	157.24	10.62
River in the Pass	164.50	7.36

The following localities are not on the line of the trail:

	Distance from the Colorado.	Intermediate distance.
Indian Well	70.24	------------
"Soda Springs"	87.24	17.00
Salt Pond	99.24	12.00

It will thus be seen that there is no interval of over twenty-five miles without water on the travelled trail across the Desert. The whole distance from the Colorado to the foot of the Bernardino Pass is not over 170 miles; consequently, not more than three watering stations will be required on the Desert for railroad purposes. The distance from the mouth of the Gila, in a direct line, to the water in the Pass, measured without regard to the localities of water on the Desert, is about one hundred and thirty miles. There are doubtless many other localities of water that have not yet been discovered. It is, however, my opinion that water can be obtained at almost any desired point by digging or boring.

It is very important that the wells should be improved, or, rather, that others should be dug at convenient distances along the route usually travelled from the Colorado to Carrizo Creek.

The lives and property of emigrants and travellers require that they should be dug; and they are necessary to the safety and comfort of the wagon trains carrying supplies to Fort Yuma from the coast. The travel between the Gila and California is constantly increasing, and large droves of cattle and sheep from New Mexico are driven over the Desert. The present mud-holes should be at once replaced by carefully constructed wells, capable of holding water enough for a large number of men and the animals of a train. The wells should be carried to a considerable depth, and thoroughly and securely timbered and planked throughout. Iron troughs[1] and buckets should be furnished, and a narrow iron curb, securely bolted down, would be better than one of wood. "Deep Well," at the base of San Gorgoño Mountain, should be carried to a greater depth, and be much enlarged. It should be lined with stout plank, and timbered in the manner before suggested. A well is very much needed near or at the Big Lagoon. It can be easily dug in the clay, and a good supply of water would probably be obtained. Wells ought also to be dug at several points intermediate between the Lagoon or Sackett's Well and the Salt Creek, and likewise between Salt Creek and the Cohuilla Springs. A few thousand dollars judiciously expended would secure an abundance of water in wells along the whole line.

As there has not been an opportunity to give the waters from the Desert a chemical examination, it is impossible to present a full and definite statement of their quality and mineral ingredients. The water that is obtained from New River and its lagoons appears to be tolerably free from soluble salts. It is only when the water in the lagoons is very much concentrated by evaporation that it becomes brackish, and shows the presence of salt by a slight incrustation on the shores. A very considerable quantity of fine clay is, however, held in suspension by the water, and when it has been long standing in the sun it becomes more or less charged with organic impurities. The water from the different wells appears to be nearly alike; it is slightly brackish in all of them. The water also holds a portion of clay in suspension, sufficient to impart an earthy, disagreeable taste. The quantity of salt present in the water is not enough to injure it for culinary purposes, and it is hardly perceptible to the taste. The peculiarity of the water of the Soda Springs has been described. From the statement of Mr. Poole, I am led to believe that the water is remarkably pure. Its chief mineral ingredient will probably be found to be carbonate of lime. The hillocks surrounding the springs probably are not wholly composed of a deposit from the water. In that region, and in the Great Basin, the springs are commonly surrounded by a mound or elevated border, formed from the accumulation of sand and dust upon the moist earth, and among the roots of the grass and other vegetation.

The springs at the Cohuilla villages contain soluble salts in small quantities. Some of the salts showed their presence by a white border on the edge of the water, and by the growth of the peculiar "salt grass," common on the borders of salt lakes. The water of Hot Spring appears to be very pure, and free from any solid impurities. The unpleasant odor of sulphuretted hydrogen is removed when the water is boiled.

The principal facts leading to the conclusion that a persistent supply of water may be obtained by wells may be recapitulated as follows:

1. The surface of the deep clay, which has already been described as having been deposited by a former lake or bay, and which now constitutes the greater part of the Desert, is not, at any point, many feet above the Colorado, and is, in great part, below it.

2. It is at times irrigated by the overflows of the Colorado, through New River.

[1] It has been found almost impossible to keep wooden buckets and troughs at Alamo Well. The buckets are stolen by travellers, and the troughs are used for fire-wood.

3. The lower level, or terrace, bordering the Colorado, and extending far inland, is thickly wooded near the Mezquite Well with mezquite, and near the Colorado with willows and cotton-woods. These plants show the presence of water at no great depth below the surface.

4. The deep clay is very retentive of moisture, and evaporation from its surface is slow.

5. Water being found in several distant places, at apparently the same level, and below the level of the Colorado, indicates that the supply is derived, partly at least, from that stream, by infiltration.

In view of these facts, and the experience of travellers, in relation to the wells, I do not hesitate to assert that, when judiciously constructed, ordinary wells can be relied upon for a constant and abundant supply of water.

There are many other points, intermediate to the wells, where water can be obtained by digging. Indeed, it will probably be found at almost any part of the lower terrace upon which the mezquite grows so abundantly. The natural springs of the northern part of the Desert may be regarded as unfailing, and they can be made to furnish a supply of water sufficient for all railroad purposes.

Artesian wells.—In addition to the water that can be obtained from common wells in the clay, there is every reason to believe that deep Artesian borings would be entirely successful. The clay formation rests upon stratified Tertiary sandstones and shales which are more or less tilted and disturbed by intrusive rocks. The edges of these strata appear at the surface at Carrizo Creek and along the base of the Peninsula Sierra. Although there is comparatively very little water supplied from the inland slope of these mountains, yet, in the aggregate amount, it is probably sufficient to keep the strata under the clay charged with water. The strata may also receive a supply from the Colorado. The clay formation acts as a retentive superstratum; by perforating it, and reaching the underlying strata, it is probable that a copious supply of water would be obtained; in some parts of the Desert, it would overflow the surface. Such wells would be of great value in that region for irrigation.

In the event of the location of the railroad upon the upper terrace, or gravelly plateau to the north of the Sand-Hills, it may be desirable to obtain water there. It can be most conveniently done by boring; and the depth to which the perforation must extend will necessarily be much greater than if commenced on the lower plain or first terrace. The probabilities are that water would be found; but, in that vicinity, it cannot be expected to rise to the surface.

If the railroad is constructed on this upper plain, it will be north of the boundary line, and avoid the long detour to the southward along the trail, which is in Mexican territory. A straight line from the Gila to the Bernardino Pass crosses this upper plain, and nearly intersects the Soda Springs and the Salt Pond. The fact that water rises in springs in the lower and central parts of the Desert is important, and gives additional reason to believe that Artesian borings would be attended with perfect success.

AGRICULTURAL CAPABILITIES OF THE SOIL.—CLIMATE.

The upper or gravelly plains of the Desert, especially those in the vicinity of the mouth of the Gila, are too arid and wanting in soil to be ever used for agriculture. But this is not the case with a large part of the Desert—that part formed of the alluvial and lacustrine clay. The whole of this clay surface may be considered as capable of supporting a luxuriant growth of vegetation, provided it is supplied with water by irrigation. It is undoubtedly of nearly the

same composition as the alluvial bottom-land of the Colorado, which is covered with a growth of mezquite, cotton-wood, willows, and grass. Good crops of corn, beans, and melons are also raised by the Yuma and Cocopas Indians. The river-bottom of the Gila is said to be adapted to the growth of cotton—it being cultivated by the Pimo Indians, who have long been known to manufacture cotton blankets. Other evidences of the fertility of the clay, when moistened, are presented by the vegetation on the borders of the lagoons, and on the banks of New River, which are said to be covered with a dense growth of grass. It is, in part, for the use of this grass that the emigrants prefer the trail along the stream to the shorter one, under the sand-hills, by Cooke's Well and Alamo Mocho.

The Cohuilla Indians, in the northwestern part of the Desert, raise abundant crops of corn, barley, and vegetables in the vicinity of the springs at their villages. We also observed a dense growth of weeds over a wide area near the mountains, but not far from the cultivated fields. The ground upon which they grew was moist and miry, being supplied with water by numerous springs. The barley-field found near the sand-hills, at the base of the Bernardino Pass, was upon the clay of the Desert; the thickness and size of the stubble was such as to indicate a large yield.

The specimens of the soil near the Cohuilla villages, which were procured for analysis, are rich in all the mineral ingredients necessary to fertility. The examination of the sample showed the presence of the following substances:

Soluble in water.	*Soluble in acid.*
Alumina and oxide of iron.	Silica.
Lime.	Clay and oxide of iron and manganese.
Magnesia.	Carbonate of lime.
Soda, (abundant.)	Magnesia, (unusually large.)
Potash, (abundant)	Phosphoric acid.
Phosphoric acid.	Sulphuric acid.
Sulphuric acid.	Soda.
Chlorine.	Potash.
Organic matter.	

The per-centage of the sand, organic matter, carbonate of lime, and the soluble salts was determined by weight with the following result:[1]

Sand	60.00 per cent.
Carbonate of lime	16.59 per cent.
Organic matter	1.30 per cent.
Soluble in water	1.58 per cent.

This may be called an exceedingly rich soil, and is adapted to various crops. The large amount of carbonate of lime is due, in part, to the presence of the small shells distributed through the soil. The amount of organic matter, though not by any means very small, would be rapidly increased by cultivation.

From the preceding facts it becomes evident that the alluvial soil of the Desert is capable of sustaining a vigorous vegetation. The only apparent reason for its sterility is the absence of water, for wherever it is kept moist vegetation springs up. If a supply of water could be obtained for irrigation, it is probable that the greater part of the Desert could be made to yield crops of almost any kind. During the seasons of high water, or the overflows of the Colorado, there would be little difficulty in irrigating large areas in the vicinity of New River and the lagoons. By deepening the channel of New River, or cutting a canal so low that the water of the Colorado would enter at all seasons of the year, a constant supply could be furnished to the

[1] See Appendix, Article VII, Chemical Examinations.

interior portions of the Desert. It is, indeed, a serious question whether a canal would not cause the overflow of a vast surface, and refill, to a certain extent, the dry valley of the Ancient Lake. This is possible, and would result, provided no change of level has taken place since the waters dried up. An overflow and submergence of the valley would produce great changes in the climate of that region, and permit navigation by small vessels from the Colorado to the base of the Bernardino Pass.

In considering the adaptation of the surface of the Desert to agriculture, the peculiarities of the climate should be remembered. It is possible that they are such as to prevent the successful cultivation of crops, however rich and favorable the soil may be. The air is peculiarly hot and dry, and would have a burning and parching effect on vegetation. At certain seasons, and on parts of the Desert, the violence of the wind would greatly interfere with the growth of plants.

The prevailing winds at Fort Yuma are from the north and northwest, but southerly winds blow from June to October. The winds from the north are very dry and violent. They sweep down from the desert valleys and barren mountains, along the Colorado and the eastern side of the Great Basin, and before reaching Fort Yuma are deprived of what little moisture they may have contained. They keep the air filled with clouds of dust, and heap up the sand-hills along the terrace. The violence of these winds is, however, not so great in the valley of the Desert, it being partially protected by the ranges on the northeast side; while at Fort Yuma the full force of the current down the valley of the river is experienced. The direction of the winds, and the temperatures for the different months of the year will be found in the following table, extracted from the meteorological register kept at Fort Yuma.[1]

Months.	Thermometer.			Winds.	Rain.
	Monthly mean.	Highest.	Lowest.		
1852.	°	°	°		*Inches.*
May	81.85	108	52	W. & SW.	------
June	91.66	106	68	SW. & W.	------
July	93.54	108	70	S. & SW.	.28
August	92.74	108	70	S. & SE.	.33
September	84.56	106	60	S. & SE.	1.45
October	73.09	98	50	N. & NE.	------
November	61.83	90	38	N. & NW.	.35
December	56.51	75	32	N. & NW.	.04
1853.					
January	60.32	80	37	N. & NW.	------
February	58.71	78	36	NW.	------
March	67.56	92	40	WNW.	.10
April	74.90	98	52	NW. & W.	------
May	77 12	99	52	NW. & W.	------
June	89.04	116	61	NW. & W.	------
July	94.93	111	76	S. & SE.	.25
August	92.11	110	76	S. & SW.	------
September	89.08	110	69	N. & NE.	.04
October	79.30	100	50	N. & NW.	------
November	65.89	86	45	NE. & NW.	.18

[1] This register has been carefully kept by Dr. Milhau, U. S. A., who kindly furnished me with the above abstract.

MIRAGE ON THE COLORADO DESERT

The remarkably high range of the thermometer, exhibited by this table, cannot fail to be noticed. It is very common to find it standing at 110° during the day, but after the sun descends the temperature rapidly decreases, and the nights are refreshingly cool. The mean temperatures of the seasons, deduced from the observations of the last five years, are as follows: Spring, 72.10; Summer, 89.95; Autumn, 75.69; Winter, 56.80. The mean annual temperature being 73.62.[1] The sudden diminution of temperature at night is facilitated by the absence of clouds, or watery vapors, in the air, which allows free and rapid radiation of heat from the surface, and permits the sun's rays to penetrate with remarkable heating power and chemical effect during the day. The nights and mornings, during our stay upon the Desert, and at Camp Yuma, were always cool and comfortable, and sometimes cold, but with the rising sun the heat returned, lasting, without intermission, until the unclouded sun was hid behind the western mountains. Similar conditions were observed by Bayard Taylor in the Nubian Desert. The temperature varied from 50°—55° at 6 a. m. to 80°—85° at 2 p. m. The extremes being 47° and 100°.[2] The heat, therefore, is not as great as on the Colorado Desert.

The remarkable purity of the air of the Desert has been noticed in the Itinerary. It is so clear that it permits small objects to be distinctly seen at great distances; and the mountain ridges, when ten or twelve miles distant, appear close at hand. Small objects on the broad plain are often imagined to be of immense size, and at a great distance, there being nothing with which to compare their magnitude. The air also appears to produce a wonderful effect in coloring the ranges of distant mountains. The tints which they assume are beautifully clear and uniform, but vary with the distance. A deep, beautiful blue is most common, but all shades of brown, purple, violet, and even rose, are seen. The transparency of the air becomes very evident at night, when the stars shine out with all the splendor which they have in the clear nights of mid-winter in New England.

All the phenomena of *mirage*, as described by travellers of the Desert regions of Africa and Asia, are exhibited on a grand scale upon the Colorado Desert. Mountain ranges, so far distant as to be below the horizon, are made to rise into view in distorted and changing outlines. Inverted images of smaller objects, and apparent lakes of clear water, are often seen, and invite the traveller to turn aside for refreshment. The first exhibition of mirage that was seen was from the margin of the plain at Carrizo Creek, looking towards the Gila, about ninety miles distant. It was early in the morning, and the eastern sky had that golden hue which precedes the rising sun. Tall, blue columns, towers, and the spires of churches, and overhanging precipices seemed to stand upon the verge of the plain. Their outlines were changing gradually, and as the sun rose higher they were entirely dissipated. Figures of these outlines are given in the Itinerary.—(See also View XII.) After reaching Fort Yuma, and witnessing the strangely precipitous and pinnacled outline of the mountains beyond, it was at once apparent that the mirage consisted of their distorted images. When we were upon the northern part of the Desert, the peak of Signal Mountain was often distorted and raised above the horizon. The points of distant ranges also seemed, at times, to be elevated above the surface, precisely as headlands of a coast sometimes appear to rise above the water at sea. Many of the phenomena called mirage are not due to refraction, but are believed to be the result of reflection from the sand or smooth surface of clay, or the polished pebbles. The smooth clay forms an excellent reflector for all the rays which are incident at a slight angle, and is most frequently the cause of the

[1] Army Meteorological Register, from 1843—1854, p. 641.

[2] Journey to Central Africa, p. 180.

appearance of water. The beautiful surface of the pebbly plain may be regarded as a combination of myriads of reflectors; for each pebble is so highly polished that it reflects light almost like a mirror. The reflection from such a brilliant surface, when seen at a favorable angle, looks like a sheet of water; the similarity being heightened by the motion of the stratum of heated air in contact with the surface.

It is probable that the sand also acts as a reflecting surface, in consequence of the rounded form of the grains; a portion of the incident rays being similarly reflected from every grain, and not wholly dispersed in various directions, as they would be if the grains were angular, or had flat surfaces.

The influence which is exerted by climate upon the vegetation of a region cannot be more strikingly shown than by a comparison of the deltas, or alluvial lands, of the Mississippi and the Colorado. The alluvium of the Mississippi is noted for its fertility and the luxuriance of its vegetation. The produce of its plantations enriches States and affects the commerce of the world. On the Colorado, a short distance back from the immediate borders of the river, we find a broad alluvial plain, with a gray, ashy surface, parched and sun-baked, so that it may be quarried in blocks like stone. Scarcely a spire of grass rises above its surface, and there is no shade from the burning sun. The air, heated by radiation and direct contact with the clay, and unresisted by vegetation, is thrown into violent currents, and sweeps over the plain, bearing clouds of dust and sheets of sand with such power and persistence as to abrade and polish every obstacle.

CHAPTER XVIII.

NOTES IN THE GOLD REGION.

San Francisco to Stockton.—Great inland current of air through the Golden Gate.—Alluvial formation at Stockton.—Slope and horizontal strata.—Knight's ferry.—Basalt.—Mica and clay-slate, "grave-stone slate."—Plateaux of basalt.—Sonora.—White limestone.—Gold.—Irregular surface of limestone.—Abbey's ferry.—Cave.—Murphy's.—Teeth of elephas and mastodon.—Mammoth trees.—Sequoia gigantea.—Cave city.—Limestone and cave.—Talcose slates and gold.—Mokelumne hill.—Cosumnes river.—Sacramento.—Alluvium.—Granite.—Clay slate.—Basalt.—Auburn.—Yankee Jim's.—Auriferous alluvia.—Forest hill.—Placer mine.—Crystalline gold.—Drift at Sarahville.—Fossil wood.—Michigan city.—Auriferous drift of quartz bowlders and gravel.—Hydraulic method of mining.—Sluicing.—El Dorado aqueduct.—Serpentine.—Cañon of the north fork.—Nevada and Grass valley.—Quartz veins and mines.—Grass valley to Coloma.—Granite and slates.—Sutter's mill.—Slates and trap dikes at Irish creek.—Crystals of gold.—Georgetown.—Mamaluke hill.—Slates and auriferous drift.—Method of mining.—Washington tunnel company.—Rich vein of auriferous quartz.—Deposits at Cement hill.—Bed of an ancient river.—Collecting the gold from a sluice.—Minerals.—Telluret of silver.—Serpentine.—Volcanoville.—Rich specimens.—Mormon island.—Granite.—Concluding observations on the geology of the gold region.—Talcose and clay slates.—Erupted rocks.—Belt of granite.—Belt of metamorphosed limestone, possibly carboniferous.—Horizontal strata, tertiary.—Overflows of basaltic lava.—Table mountains.—Auriferous drift.—coarse drift.—River drift.—Alluvial deposits.—Lacustrine deposits.

SAN FRANCISCO TO SONORA.[1]

August 4, 1854.—Left San Francisco in the high pressure steamboat "American Eagle" for Stockton at 4 o'clock in the afternoon. In passing up the bay we experienced the full force of the great air-current that sweeps in from the ocean to the interior. The Golden Gate is like a great draught-channel through which the cold winds reach the heated plains on the other side of the Coast Mountains. The wind pours in with such violence that a heavy swell is constantly rolling in the channel, and small steamers roll and pitch as if there was a severe storm. The wind prevails from April to November.

The small island beyond Angel Island, rising like a pinnacle in the bay, is formed of red rock similar to that of Lime Point, and it is probably the same metamorphosed formation. The wild-oat covers the hills so thickly that they seem like vast, unreaped fields of grain. The fires have not traversed as much of the surface as last year, when nearly all the hills in the vicinity of Benicia were burned off, leaving only a blackened surface, and the bare and sun-baked soil.

A very perceptible change in the climate is felt soon after leaving San Francisco. The high ranges between the bay of San Pablo and the Pacific prevent the rush of air which passes so freely in at the Golden Gate, and appear to act the part of barriers, or a wall, to break the force of the wind. There is, apparently, less moisture in the air, and its temperature is higher.

August 5.—Arrived at Stockton early in the morning, and soon left by stage for Sonora. Stockton is built on the margin of a slough of the river, and is upon the alluvial clay of the delta. We soon pass from this clay to the firmer and more gravelly materials of the long slope of the valley, which reaches up to the foot-hills of the mountains, precisely as we find it further south along the Tuolumne or other streams. This slope has a very gentle upward inclination

[1] This chapter embodies a part of the notes which were made during a rapid tour through the Gold Region in the summer of 1854. A sketch-book in which the route for each day was rudely plotted, with notes upon the rocks and their succession, and sections of the drift deposits, was stolen, with other articles, on the Isthmus, in returning to New York. It has thus been impossible to present all the observations which were made, or to connect upon a map, those now given.

for about twenty miles, without a single hill to break the monotony of the surface. The wide plain is dotted with splendid oaks, *Quercus Hindsii,* which give it a park-like character like the valley of San José.

At the distance of twenty miles from Stockton a gentle undulation of the surface is observable, and long, gently sloping hills of slight elevation are visible on each side of the road. Horizontal strata crop out in long lines on their sides, and they appear to be the remains of a former slope of Tertiary deposits. Hills of this character soon limit the view on each side, and are found as far as Knight's Ferry, on the Stanislaus. At this point they are no longer low hills, but rise high above the stream, forming almost precipitous banks, in which the strata are distinctly exposed. The wide opening made by the river permits the outlines of distant ridges or plateaux to be seen, and they present a magnificent appearance. The strata lie piled together nearly 2,000 feet thick, and their nearly horizontal edges can be traced for miles. The distant hills are evidently the margins of a plateau or gentle slope, once the bottom of a Tertiary sea. This exposure of strata is several miles south of the ferry, but similar bluffs, though of less altitude, face the river a short distance below the crossing. Here the sandstone beds are hard, and the river flows over them in rapids. The tops of the banks are covered with large, round blocks of basalt or amygdaloidal volcanic rocks, and they appear to have been derived from the edges of a horizontal layer in the vicinity. There are indications of a great dyke cutting through the strata, but it may be older than them, and the beds may have been formed around it. Recent overflows of basalt are, however, not far distant, and the distant plateau is probably covered in part by this roof-like protector from rapid denudation.

Mining operations are conducted all along this part of the Stanislaus, and the tributary ravines, in the river-drift or gravel and sand of its bed and shores. On crossing the river, and rising the opposite bank, abundance of round, weather-worn masses of basaltic rock were found; they are probably from a dyke or overflow. The old metamorphic or Azoic slates crop out a short distance beyond. They are talcose and chloritic, and are nearly vertical; standing out in high slabs, arranged in lines like grave-stones. They are called *grave-stone slates* by the miners; and, in fact, are the tomb-stones of past ages. The road extends nearly at right angles to the trend of these slates, and I traversed a vast thickness. The country is open and undulating, and there are but few trees. The ascent became more and more rapid, and at Green Spring Cottage the aspect of the landscape had changed. Green trees and grass-covered slopes succeeded to the bare and parched hills. From Green Spring Cottage there is a beautiful view towards Burns' Ferry, and the edges of distant plateaux are visible, and a gap in them made by the river. The summit of these plateaux is formed of basalt, and the rock weathers with bluff margins, precisely as along the San Joaquin at Fort Miller. This plateau at Burns' Ferry must be much more elevated than that seen at the south of Knight's Ferry.

At Montezuma, and in the vicinity, there are extensive alluvial flats from which much fine gold is taken. The earth and stones of a great area have been excavated to the bed-rock and washed.

Jamestown, three miles beyond Montezuma, and four from Sonora, is a thriving mining village. Wood's Creek, upon which it is situated, was one of the richest for its extent in California, and is celebrated for its abundant yield of gold.

Sonora, though far in the mountains, has its churches, hotels, bath-houses, and other accompaniments of cities of older and slower growth. It is one of the largest and most thriving towns in the mining districts south of Mokelumne Hill.

Visited the mill of the "Tuolumne Quartz Company." It is provided with an engine of

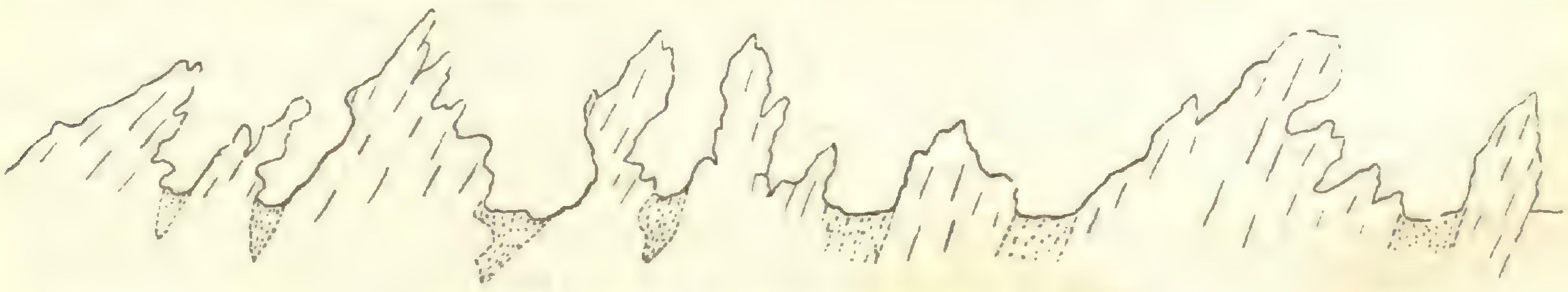
sixty horse-power, eighteen stamps, and a Chillian mill. The gold is chiefly caught upon blankets, and in ripple-boxes provided with amalgamated copper cleats. Shaking-tables and bowls are not used. The veins trend N. and N. 22° E., and the quartz contains cavities stained black with oxides of iron and manganese. Several specimens in which the gold was distinctly visible were shown to me by Mr. Smith, the superintendent; but in general the quartz is much stained by the decomposition of pyrites, and the gold does not appear. The pile of ore ready for the stamps was almost identical in its appearance with the quartz from the upper parts of the veins in Virginia and the Carolinas.

SONORA TO MURPHY'S.

August 6.—We left Sonora and travelled towards Murphy's, passing through Shaw's Flat, Springfield, and Columbia. Extensive outcrops of white limestone were passed, and the town of Columbia is built upon this formation. The town was completely destroyed by fire in July last, only two buildings having escaped; but it is now nearly rebuilt, and business is going forward as before. Fire-proof brick stores are in progress, and Gothic cottage residences grace the outskirts of the place.

The white limestone which underlies the vicinity is peculiarly compact and finely granular, and is seamed and veined with blue; in some parts appearing like a mixture of blue and white grains, forming a marble of good quality. The blue lines are, however, generally parallel, or in layers corresponding to the trend of the beds. The surface wears unequally, so that it is furrowed in long lines, making the trend of the outcrops still more distinct. These layers, or beds, brought out so distinctly by weathering, are probably the result of deposition, and the rock gives many evidences of sedimentary origin, except fossils. The crystalline structure does not favor this view of its origin, but it is doubtless metamorphic.

The gold from the vicinity of Columbia is very fine, and commands high prices; $18 and $18 50 being paid for it by the ounce, at the express offices. Nearly all of the gold is taken from the deep crevices and fissures of the limestone, at variable depths from the surface—from four to twenty-five feet. The peculiarly irregular character of the underground surface of the limestone is worthy of particular notice, and it is well exposed to view by the excavations. Wherever the earth is removed, irregular columns and sharp pinnacles of the rock are left standing; some of them being supported on a narrow neck at the base, and are thus in a con-



IRREGULAR SURFACE OF LIMESTONE EXPOSED BY MINING.

dition to be easily overturned when the surrounding rock is removed. The fissures or spaces between some of the masses are so narrow and crooked that the rock has to be broken away to permit the removal of the gravel and gold from the bottom. Many masses are found entirely loose and disconnected from the subjacent rock, and are found to end in a long, sharp point projecting downwards, while the upper portions are several feet in diameter. These loose masses are broken up and removed by the miners, and are generally supposed to be boulders r transported fragments. It is evident, however, that they are not erratics, but that they are

formed by the decomposition of the rock. The spaces between these vertical crags of limestone are filled in with earth, clay, and gravel, and large fragments of slate. Gold is found in a stiff, blue clay, at the bottom and sides of the spaces.

All the phenomena point to a most remarkable and rapid solution of the surface of the limestone, and it appears to have taken place *after* the surface was covered with the auriferous deposits. Such a surface could never be formed by denudation or the wearing action of currents; it is totally different, and the irregular and ragged, yet smooth, surface of the blocks shows the action of solvents, and is not the result of attrition. The imbedded pear-shaped masses of limestone, with the points downwards, show the action of solvents subsequent to the deposition of the gravel, for they are supported by it. If the solution of the rock has thus been subsequent to the deposition of the auriferous clay and gravel, these accumulations must have sank downwards by their own weight as rapidly as the underlying rock was removed. This is indicated by the fact that gold is found imbedded in blue clay on the *sides* of some of the vertical masses of limestone, while the adjoining materials, at that level, are merely coarse gravel and fragments of slate. A portion of the clay, containing the gold, would thus appear to have adhered to the sides of the fissure, while the central portions were forced downwards by the weight of the superincumbent materials. I am unable to account for these conditions in any other way. It is not possible to determine the nature of the solvent with certainty, but it is most probable that it was acidulated water formed by the decomposition of pyrites in the drift and soil, or, possibly, water charged with carbonic acid alone. The whole surface may have been submerged for a long time, forming the bottom of a shallow lake or marsh. This is indicated by the uniform deposition of the clay and other materials over a wide area. It is, however, quite possible that all the decomposition has been accomplished by percolating water alone, since the surface became nearly or quite dry. An enormous quantity of limestone has been removed, the fissures in many places being over twenty-five feet deep, and the solution must have drained away underground towards the river, or formed deposits of gypsum or travertin in the vicinity. The general appearance of the cross-section of a broad excavation among these projecting crags is shown in the figure, the trend and inclination of the limestone being retained by the remaining masses. It is probable that at some points the spaces between the masses of limestone extend downwards for a very great distance, and may have been worn by subterranean currents far beyond the reach of ordinary mining operations. The gold obtained from these deposits is coarse, but seldom exceeds the size of peas or beans.[1]

A part of the blue clay from this vicinity is exceedingly rich in fine gold, but its tenacity and toughness prevents the gold from being readily washed out. The clay is, therefore, raised to the surface and spread out to dry in the sun, and is afterwards pulverized and then washed. Enormous teeth, both of the Mammoth and Mastodon, have been obtained here in considerable numbers, but I was disappointed to find that they had all been burned in the recent conflagration. It is said that some of them were imbedded in the jaw. At another flat, several miles beyond, a large tusk was exhumed, but, being exposed to the weather in front of a miner's cabin, it soon fell to pieces, and was lost.

We descended long and very steep hills to the level of the Stanislaus River and crossed by Abbey's Ferry. Granite was observed. The slopes of the River cañon are wooded with pines and oaks. Granite and white limestone were observed after crossing; the limestone trending

[1] Sir R. I. Murchison gives a figure of an eroded and irregular surface of limestone in the Urals, from which auriferous alluvia had been removed by mining. This surface was, perhaps, formed in the same manner as the irregular surface of the limestone in California.—*Russia in Europe and the Urals*, i, p. 487. *Siluria*, p. 442.

N. 60° to N. 75° W. It is intercalated with mica-slate in thin layers. A trap dyke four feet thick was found after gaining the level of the plateau or "divide." It traverses the limestone, and trends N. 45° E., S. 45° W., following the stratification or structure of the limestone. Basalt occurs beyond, in a horizontal layer, and, on approaching Douglas Flat, the margin of a broad plain of this rock is visible high up on the tops of the ridges.

We passed the mouth of a cave which has recently attracted so much attention, from the fact that upwards of sixty human skulls, with bones, were found in it under a layer of black mould. A pile of the bones was lying near by; judging from their appearance, they are of great antiquity. Indian relics, arrow-heads, and perforated sea-shells, were found with them. An old Indian states that, long before white men were seen in California, the northern Indians came down to this valley and met his ancestors in battle. A great number was killed on both sides, and, it being almost impossible for them to burn the bodies of so many, they were thrown headlong into the mouth of the cave and were never afterwards disturbed. Whether this is the true account of the accumulation of these remains there or not, it is impossible to say. It seems very probable.

Extensive mining operations are carried on at Murphy's in a flat behind the village. The whole area is claimed, and mostly dug over. The drift is coarse, and consists, in great part, of fragments of talcose slate, from three to six and eight or more inches in length. A fine specimen—the tooth of a mastodon—was exhibited to me, but could not be obtained. It was much worn. Another specimen was described as having been formed in plates, "which were split apart so as to give a tooth to each owner in the claim;" this was doubtless a molar of a mammoth or *Elephas primigenius*. Many of these relics of the past are thus destroyed, or they are carefully preserved in obscurity. If they are ever offered for sale, it is at the most absurd and fanciful prices.

MAMMOTH TREES.

August 7.—We left Murphy's in the afternoon for the grove of "Big Trees," about fifteen miles distant. We soon entered a narrow valley, and commenced ascending the cañon of a small stream. The hills on each side were partially covered with oaks, and afforded an agreeable shade from the sun, after traversing the almost treeless flats. The aqueduct of the Union Water Company is constructed along this valley, and we caught occasional glimpses of the flume stretching across the ravine, and high in the air among the topmost branches of the pines and oaks. These flumes, and the canal, are of sufficient capacity to carry the water of a good-sized mill-stream. The canal is about five feet wide, and is thoroughly made. It, with the flumes, is said to extend ninety miles. The capital stock of the company is $200,000, and two dividends, of four per cent., have been paid, or eight per cent. for two months. It being in contemplation to extend a branch to connect the upper end of the aqueduct with the head-waters of the Stanislaus, the dividends are now withheld. It is expected that the extension will provide a most abundant supply of water, not only for mining, but agricultural purposes.

As we proceeded, the surface became more undulating, and we rode through dense forests of tall pines, towering up as straight as a liberty pole for two hundred feet or more. The soil appeared deep and rich, and there were very few outcrops of rock. The absence of underwood permits the surface to be seen for a considerable distance on each side.

These giant pines stand so widely apart, and are so free from limbs up to a height of fifty or seventy feet and more, that vision can extend, under their shade, to a great distance. The

grandeur of the scene cannot be described ; it must be seen to be felt. The surface is moulded on a scale commensurate with this mighty forest. It rises in graceful swells, miles in extent, into mountain-like elevations, so smooth and rounded that a carriage may be driven almost anywhere among the lordly trees.

About sundown we reached an eminence, and commenced descending into a sheltered valley. The hills on all sides were densely covered with pines and spruces, and there was some undergrowth. The shadows became more dense, and at dark we reached the level of the valley, passing on our way one or two giant trunks, which rose above the gloom of the forest into the twilight above. We dismounted at the door of "Big Tree Cottage," a comfortable frame building erected by Mr. Lapham, where we passed the night, surrounded by the shadows of the most magnificent forest yet known on earth.

August 8.—This valley is sheltered on all sides, and it has a very deep and moist soil. This was shown by the earth thrown out when the well was dug ; it is nearly all granitic sand and gravel and fine clay. The only rock observed was a compact, gray granite, and some round basaltic blocks, on the surface of the hills on one side of the valley. This depression is so much sheltered by the ridges and high forests around that there is little violent wind ; and it is said that the ground does not freeze to a great depth in winter, although there is about thirty inches of snow from January to April. The elevation is estimated at 2,400 feet above Murphy's, and 4,550 above the sea. These results are reported to have been obtained by Captain Hanford, the engineer of the Union Water Company. The crest of the Sierra is about thirty-five miles distant, but the lowest limit of the snow is only fifteen miles.

The first of the great trees that claimed our attention is at the side of the cottage, and lies prostrate upon the earth. It was cut down by boring through it with pump-augers about six feet above the ground. This operation employed five men for three weeks. The stump being nearly flat, was smoothed off perfectly level, and now forms the floor of a good-sized room connected with the house. The solid wood of this stump—for it is sound to the very centre—is *twenty-five feet* in diameter, and, adding the thickness of the bark, the whole diameter is about twenty-eight feet ; lower down, at the surface of the ground, it is probably thirty-two or thirty-three feet. The largest tree now standing, called the *Mammoth*, is about the same size, but is imperfect on one side, a portion having been burned out by a fire at the roots. This tree was carefully measured with a tape, and its circumference found to be ninety-four feet, giving about thirty-one feet as its diameter.

Mr. Lapham states that he has counted about one hundred and ninety trees, including the young and old. Of those of such gigantic proportions, however, there appears to be only about twenty, and these vary in their diameters. The principal trees have received fanciful names, such as, *Father of the Forest*, *Beauty of the Forest*, *Pioneer's Cabin*, *Three Sisters*, *Old Maid*, *Mammoth*, &c. Although I did not measure the heights of these trees, I saw no reason to question the accuracy of the statements that have been made, and I believe them to range from three hundred to three hundred and sixty feet in height. One is said to be three hundred and sixty-three feet ; and an old one, lying prostrate, and much decayed, appears to have been over four hundred feet high. The prostrate tree is hollow, and I walked through it erect for a long distance. It is said that, before the lower part became filled up by earth and stones, brought in by a brook, a man could ride through on horseback. Most of the trees appear to have been much broken and deformed by the storms of centuries. The limbs are very short and thick, the foliage appearing to be in thick bunches around the trunk. The most perfectly formed tree of

MAMMOTH TREE "BEAUTY OF THE FOREST."

the group is called the Beauty of the Forest, and it is favorably exposed to view by the clearing which has been made around Mr. Lapham's hotel. A sketch of it is presented with this report, View XIV. It is said to be only fifteen feet in diameter at the base, and three hundred and twenty-five feet high. It is surrounded by a forest of large pines and firs and a thick undergrowth of small trees.

The tree which was cut down was partly used for lumber, and a part of the top has been levelled off, and a full-length double bowling-alley built on it. The log tapers so gradually, and its great diameter is so well preserved for a long distance, that at the extreme end of the alley it is not possible to get from the ground to the top of the log without climbing up by the limbs. The bark was stripped off from the lower part of the log and sent away for exhibition. Since that time a second tree has been stripped of its bark to the height of ninety feet, and the tree is still standing. It is the intention of the proprietors of the grove to surround it with a spiral staircase, so that visitors may ascend to the top, and have a full view of the surrounding forest, with here and there a giant trunk rising above it.

It had been stated that these gigantic trees were about 3,000 years old, and this appeared to be the belief at the locality. The end of the great, fallen trunk, which had been cut square off by a cross-cut saw, was favorably exposed for examination, and all the rings of annual growth could be distinctly seen. A portion of this was measured, and the rings were counted; the result was, that I became satisfied that the tree could not have been more than 1,200 years in attaining its growth. If time had permitted, the exact age, as far as indicated by the annual rings, would have been determined.[1]

CAVE CITY.

From the Mammoth Grove we passed by a horse-trail, or bridle-path, over the hills for about eighteen miles to *Cave City*, a new mining town near a great cave in the limestone. Soon after leaving the great forest-covered valley, the hills became less thickly covered, and at last they were almost devoid of trees. Granite was the chief underlying rock for the greater part of the way; but we saw great numbers of round blocks of basalt strewn over the surface here and there, as if they were derived from the weathering of a horizontal layer. The descent from the elevated region of the trees became rapid, and at length the trail skirted the margin of a broad valley far below us. At the foot of a long hill we came suddenly upon an immense mass of quartz-rock jutting out from the side of the mountain and rising some fifty or sixty feet above the trail. On gaining the top, by the aid of cedars growing along its precipitous side, we found that it formed a sheer precipice, twelve or fifteen hundred feet high, overlooking the valley. This is a most favorable point from which to view the valley; it extends for several miles in every direction, and is thickly wooded with pines. The distant ridges are also well wooded with tall, conical pines; and on the west a long line of plateaux show horizontal terraces and lines of the strata. They are over 2,000 feet high, and can be traced for miles, reaching across valleys over ten miles wide. These strata are probably a continuation of those at Knight's Ferry, Abbey's Ferry, and Mokelumne Hill.

After descending by the winding trail to the level of the valley, and crossing to hills on the opposite side, we looked back and saw a most beautiful water-fall, with a descent of about a

[1] The eminent English botanist, Prof. Lindley, on receiving specimens of this remarkable tree, regarded it as forming a new genus, and he proposed for it the name *Wellingtonia gigantea*. Prof. Torrey, having recently received a great number of more perfect specimens, decides that the tree ust be referred to the old genus *Sequoia*, and it is now known as *Sequoia gigantea*. It is similar in many respects to the redwood, *Sequoia sempervirens*.

thousand feet, pouring from the top of the ridge into the valley below. After winding about in circuitous ravines between the edges of horizontal strata, capped in some places by basaltic layers high above us, we reached the Cave House, built at the base of a ridge of the white limestone, the continuation of the same which occurs further south, at Columbia and beyond. At this point the trend is from N. 50° W. to N. 75° W., and the beds incline towards the east at a high angle. The trend is remarkably distinct, the rock being weathered in long parallel lines corresponding to what was probably the original stratification of the rock.

We entered and explored the "Great Cave." It consists of a series of passages and chambers of great extent, worn in the rock by the solvent power of water holding carbonic acid in solution. These chambers are irregular, and generally the trend of the limestone is distinctly shown in the walls and ceiling by the irregularity of the decomposition or solution of the rock, some of the layers being much more rapidly acted on than others, precisely as we find on the surface.

Several of the chambers are lined with stalactites and stalagmites of great beauty. The stalactites often reach from the ceiling to the floor of the caverns, and thus form grottos with alabaster-like walls, presenting a splendid appearance when illuminated by candles. Nearly all of the lime which is thus deposited is highly crystalline, and reflects back the light of the candles from myriads of brilliant facets. Where the calcareous water has oozed from fissures in the walls, and ran down to the floor, great deposits of the crystalline lime have been formed, and they appear at a little distance like foaming water-falls, so perfect is their resemblance to them in shape.

MURPHY'S TO SACRAMENTO.

August 9.—*Murphy's to Mokelumne Hill*, 34 *miles*.—At Angel's camp, ten miles from Murphy's, the talcose slates come into full view, and are traversed by quartz veins. At one of the mines, a thin vein of quartz bears a quantity of white iron pyrites and gold. The pyrites is also found in the adjoining slates in brilliant cubes, forming interesting cabinet specimens. The slates are light-colored, and like those which are similarly charged with pyrites in North Carolina. The veins appear to be conformable with the slates, and trend a little west of north. Several outcrops of the slate seen before reaching Angel's camp were nearly east and west in their trend, and were inclined at an angle of about 45° towards the north.

We reached the outskirts of Mokelumne Hill after dark, and came near driving into the mouth of an open pit, one of the abandoned mining shafts which line the road on each side. This town is one of the oldest in the mining region, having been commenced in 1849, and it has been noted as one of the richest mining localities in the southern mines. It is on the south side of, and over a thousand feet above, the Mokelumne river. It is well supplied with water, under a pressure of 110 feet, from a reservoir. The mining is chiefly in a coarse drift of gravel and boulders, many feet below the surface. I am informed that the gold is nearly all coarse, and that the greatest part is in grains worth from fifty cents to ten dollars. A high hill adjoining the town is composed of horizontal strata, chiefly soft and semi-consolidated clays, and fine sand of volcanic origin. They are not well exposed to view, but a part of the hill extends out in a low spur, formed of a comparatively hard stratum of a peculiar pink sandstone, composed in a great part of pumice-stone and its fine dust. This stone is quarried in large blocks, and being very light and easily cut, is sent down to San Francisco for the erection of a block of buildings. It

is not clearly marked by lines of deposition or stratification, but appears to be regularly stratified. Some of the layers are nearly white or gray.

Many shafts have been sunk into these rocks in search of the "lead" or "pay-dirt," but without any success. The layer of auriferous drift, however, appears to underlie these strata, for tunnels are excavated at the base of the hill and extend under it. Whether the drift was washed under the edges of these strata, or does in reality underlie them, being older, I could not determine in the short time devoted to the examination. The strata appear like the Tertiary of Ocoya Creek.

August 10.—*Mokelumne Hill to Sacramento.*—Left Mokelumne Hill at four in the morning, and descended a long hill to the level of the Mokelumne river, which is spanned by a neat and well-constructed bridge. The surface of the country in the vicinity of Ione Valley is rounded and undulating, and is covered by oak openings. The soil is good. The bottom-land of the Cosumnes River is very broad, and well wooded with groves of oak. There is a wide area of excellent agricultural land at this place, and many fields are enclosed with board fences. The river is a stream of considerable magnitude and flows slowly. It is crossed by a suspension bridge in one span.

After crossing the alluvial plain bordering the stream, we rise up to the level of the wide and regular slope, which is without trees, and, at this season, appears perfectly barren and desert-like. It is in all respects like the same slope further south along the San Joaquin. Distant rivers are indicated by long lines of trees, that sometimes loom up by mirage and appear to be suspended above the verge of the horizon. We traversed this broad plain towards Sacramento, stopping at three stations, where water is obtained for the horses from wells.

Sacramento is located upon the alluvial deposits of the river, and is surrounded by a levee to prevent inundations. Oaks and cotton-wood are the prevailing trees.

SACRAMENTO TO YANKEE JIM'S.

August 12.—*Sacramento to Auburn,* 40 *miles.*—We traversed the long and gently ascending slope towards the mountains. At Oak Grove, about ten miles from Sacramento, the surface is undulating and is covered with groves of oak of two species: (*Quercus macradenia,* Torrey, probably *Q. Hindsii,* Benth.,) and *Q. agrifolia.*

Granite crops out along the road about twenty-five miles from Sacramento. It corresponds very nearly with that obtained from the banks of the American River at Mormon Island. It is traversed by feldspathic, or coarse granitic veins like those at Monterey, and weathers into large, rounded blocks, which rest like great boulders on the surface. These are very abundant in some places, but are the result of slow decomposition alone ; they are not transported masses. There appears to be a very thin layer of drift or auriferous earth in this vicinity, and mining operations are in progress on some of the flats.

About four miles from Auburn outcrops of clay slate were passed, and one of the ridges is covered with loose, boulder-like blocks of basaltic rock, probably derived from a layer in place.

Auburn to Yankee Jim's, 22½ *miles.*—On leaving Auburn the road immediately ascends a ridge formed of the vertical layers of clay slate. This formation continues to the American River, which has cut its deep channel or cañon in it. The sides of the cañon are abrupt and precipitous, and probably are not less than 35° in inclination at any point in the vicinity. The road is constructed from the summit of the divide (or plateau between the streams) down

to the river, and necessarily winds along the steep sides of the cañon for a long distance, forming a zigzag descent. This road, being cut into the steep sides of the mountain, is very narrow and bounded on one side by the steep ascent, like a wall, and on the other by the precipitous descent to the river below. Both wheels of the stage being locked and placed in iron shoes, we slid rather than rolled along the road, until the bridge at the bottom of the valley was reached. The projecting edges of slate are visible in the sides of the cañon, and are very distinct in the bed of the river and on the opposite side.

The water of the river was low, and several groups of miners were seen along the dry parts of the bed mining for gold among the river-drift and sands. A party of Chinamen were thus engaged, and two of them were throwing out the water from a pit in a very ingenious manner. They stand on opposite sides of the excavation, and swing a bucket by means of four ropes. It is thrown into the water at the bottom of the pit, filled, raised, and emptied on the outside, with great rapidity and ease. The bucket is thus in constant motion, and an immense quantity of water is thrown out in a short time.

A long and tedious ascent, on the opposite side of the stream, brought us to the level of the divide, which the road follows, over a gently undulating surface, to Yankee Jim's. This mining town is pleasantly located, and is about three thousand feet above the level of the sea. The auriferous drift has been extensively worked, and its nature is well exposed in the sides of excavations north of the main street. It is here seen to rest upon the upturned edges of slate, and consists, in general, of coarse materials, much rounded and worn. Several layers consist of fine granitic sand, and they alternate with boulders imbedded in clay and masses of decomposed talcose slate. Much of the deposit is stained by oxide of iron. At one point the coarse materials were underlaid by a bed of sand three feet thick. Portions of the beds were colored black by infiltrated oxide of manganese, and at a little distance looked like beds of black sand or lignite. About six feet below the surface of the bank the trunk of a tree protruded, showing that the upper portions were of comparatively recent origin, being, probably, a wash from the hills. These banks are washed away, and the gold obtained, by the "hydraulic method"—a new way of mining, which has originated in the gold region of California.

YANKEE JIM'S TO MICHIGAN CITY.

August 14.—*Yankee Jim's to Forest Hill.*—A ride of a few miles from Yankee Jim's brought us to Forest Hill, an interesting mining locality on the north bank of the Middle fork of the American River. The surface is covered with pine trees, and it slopes rapidly towards the deep cañon of the stream, which flows full 2,500 feet below, the top of the hill being 2,800 feet above the water. There is an interesting *placer* mine at this place, owned principally by the Messrs. Deidesheimer, by whom I was hospitably entertained and conducted to all parts of their mine. The underlying rocks do not appear on the upper parts of the hill and slope, but near the entrance to the tunnel of the mine they crop out, and are exposed in the cuttings. They consist of light-colored talcose slates, partly decomposed or softened, trending north 5° to 10° east. The tunnel, or entrance to the mine, is cut through these slates for four hundred and twenty feet to the layer of drift containing the gold. The slate thus forms a *rim* or margin of a basin-shaped depression, in which the gold accumulated. At the end of the tunnel the workings diverge in different directions, and follow the surface of the bed-rock. The auriferous portion of the earth is found resting upon the edges of the slates, and is excavated in all directions, loaded into cars,

and carried out through the tunnel upon a tram-road, and dumped into a large bin made to receive it. The refuse, or *attle* of the Cornishman, is switched off from the main track and dumped in another place. The "pay-dirt," as the auriferous earth is called, is occasionally moistened with water while in the bin, and when a quantity is collected, it is washed out in a long sluice. This pay-dirt consisted, in great part, of fine talcose clay, derived from the abrasion of talcose slate, and was mingled with fragments of the slate broken from the bed-rock. On sprinkling the surface of the heap with water, the gold became visible in yellow fragments and flattened, bean-shaped masses. The gold is very coarse, and is not much worn and rounded by attrition. Many of the masses are crystalline, and are distorted and flattened octahedrons, evidently not transported far from their original source. Quartz crystals are also found in this earth, and, although the sharp points and angles are removed by abrasion, the faces retain their natural polish, and show that the agitation of the drift or gravel, with which the crystals were deposited, was not of long continuance. Many large masses of cellular quartz, from three to six and ten inches in diameter, are also thrown out from the mine, and there being no provision for crushing them, they are thrown aside. On crushing one of these in a mortar, and washing the powder, a string of "color" was obtained. It is evident that these masses were not transported far from their source, and there is a quartz vein in the vicinity without doubt.

At Sarahville, several miles beyond, the auriferous drift was exposed in bluffs, which, at one point, presented the following succession of beds from the surface downwards:

	Feet.
Blue clay	10
Clay with oxide of iron	2
White clay	2
Sand and clay	2
Sand	2
Gravel and boulders	25
Sand and gravel	4
Coarse gravel and boulders	25

The point of junction the drift with the slates was not visible, but the lower stratum of gravel and boulders probably rests upon the edges. Many of the rocks thrown out from these layers of drift are of volcanic origin. One block, over a foot in diameter, was dark-green, and broke, with a conchoidal fracture, into sharp, vitreous fragments like pitchstone. It is mottled with red and green veins, and is chiefly silex. Many of the masses of slate are very hard and highly metamorphosed.

Masses of silicified wood and even large trees turned into stone have been found in this vicinity In one claim it is said that a silicified tree was eighty feet long. A fragment of it, which was shown to me, was nearly white, but compact and glassy, every cell and pore being filled with the silica. The grain, rings of annual growth, and medullary rays were remarkably distinct. Several specimens of other masses were procured. A slab of rock or quartz was carefully preserved by one of the residents here as a great curiosity, it being covered on one side by the moss like and arborescent coats of oxide of manganese. These are generally mistaken for fossil plants. It is said that about two years ago some miners turned up a slab of this kind, very distinctly marked, and, seeing a resemblance in the outlines to the pine-covered hills, they concluded it to be a natural daguerreotype of the ridges on the opposite side of the river.

The road from Forest Hill to Michigan City winds about on the elevated plateau of the divide, among tall pines and firs, and skirts the deep cañoned valley of the Middle Fork. The stream was flowing nearly three thousand feet below us for most of the distance. These cañons are

like great furrows in a vast slope or plateau. Before reaching Sarahville we stopped at Baker's Rancho, a house beautifully located among the tall pines. There is a fine spring of pure cold water a short distance above, and a pipe from it delivers a constant stream into a large trough at the foot of a towering pine. This trough is a giant of its kind, being twenty feet long, three wide, and two deep. It is cut from a single log, and the bottom is strewn with quartz crystals and pebbles, which show distinctly through the transparent water.

Among the pines which grow so luxuriantly upon the slopes of the Sierra Nevada, the sugar pine (*Pinus lambertiana*) is one of the most interesting. Its common name is derived from the fact that a sweet, sugar-like substance exudes from the wood of the trunk where it has been cut or burnt. This is found in considerable quantities, and is well known in the mining region. In its properties it is much like *manna*, which I at first supposed it to be. It proves, however, to be a new substance, to which the name *Pinite* has been given. [1]

Michigan City.—This thriving mining town is on the north side of the Middle Fork, and about 2,000 feet above the stream. The surface was originally covered with a pine forest; but most of the trees have been cut away, and those that remain near the town are trimmed up to the very top, so that they more resemble liberty poles than trees. In June, 1852, the site was marked by but one little log cabin, and to-day it is one of the largest towns in the country. There is here a deep and widely-extended deposit of auriferous drift, covering the underlying slate from view. Whole acres of this drift have been swept away by the miners to a depth of from ten to sixty feet, or down to the "bed-rock" of slate. The edges of the slate are thus exposed, and trend N. 5° E.; they are nearly vertical, but incline slightly to the east. The surface is very uneven; and in some places the projecting layers reach nearly to the surface of the ground, thus making the thickness of the layer of drift very unequal.

[1] After my return from California I submitted a sample of the "pine sugar" to Professor S. W. Johnson, of the Yale Scientific School, who gave it a chemical examination, with the following result:

"The pine sugar had the form of rounded rough nodules, half an inch and more in diameter; some were nearly white, others were of a brown color. They were almost completely soluble in water and in boiling alcohol, yielding a reddish-brown liquid. The alcoholic solution was partly decolorized by bone-black, and a quantity of ether added to it, which caused a dense milkiness. After some hours, globular or stellate deposits of white and mostly opaque crystals were formed on the sides and bottom of the vessel, while the liquid became clear. If too much ether was added, a small quantity of syrup of uncrystallizable (?) sugar gathered in globules at the bottom of the liquid. The crystals thus obtained were further purified by recrystallization; they possess a pure and intense sweet taste, are very hard, brittle, and, unless pulverized, dissolve but slowly in boiling alcohol. A substance of bitter taste accumulated in the mother-liquors."

After having procured these crystals in a state of purity, and remarked their non-identity with mannite, &c., Berthelot's paper on several new sugars, (Compt. Rend, 1855, No. 12, p. 452, t. xli,) came to hand. This chemist describes the body in question under the name of *pinite*. He relates that it is yielded by the *Pinus lambertiana* of California, and exudes from cavities made by the aid of fire near the roots of the tree. According to Berthelot, "it possesses right polarization, and is incapable of fermentation, even after treatment with sulphuric acid. Its analysis led to the formula C_{12}, H_{12}, O_{10}. Acetate of lead-oxide ammonia precipitates from its solutions the compound C_{12}, H_{12}, O_{10}, 4 $Pb\,O$. It is isomeric with *quercite*, but differs from that body in crystalline form, and has a greater solubility and sweetness"

"The quantity at my disposal was so small that I only attempted to make an ultimate analysis; my results were slightly vitiated by the fracture of the combustion tube after the burning was complete, but before the carbonic acid had been fully carried into the potash bulbs. Below are the obtained numbers compared with those required by Berthelot's formula.

			Calculated.	Found.
C_{12}	=	72	43.90	42.75
H_{12}	=	12	7.32	7.40
O_{10}		80	48.78	49.85
		164	100.00	100.00

In another paper Berthelot describes a large number of compounds of sugars with acids. Among these are the acid and neutral stearates and benzoates of pinite. He has further found that when these compounds are saponified there is obtained the original acid, and not pinite, but a substance which gradually passes into pinite. The name *pinite* is very objectionable, as identical in orthography with one appellation of a mineral which is overleaded with synonyms."—*American Journal of Science and Arts, 2d series, vol.* xxii., p. 8; *July*, 1856.

The drift is almost entirely composed of snow-white masses of quartz, in great round blocks from three to six feet in diameter, intermingled with smaller boulders of all sizes, and gravel and sand, all of the same material. A very considerable amount of peroxide of iron is mingled with the drift in some places, and imparts a light-red color to the mass. All these blocks of quartz are very much rounded and water-worn, and the whole deposit is rudely stratified in irregular beds of variable thickness. Inclined or diagonal stratification is very distinct in nearly all of the cuttings, and shows the action of varying currents at the time of the deposition of the beds. It is probable, from the indications, that these currents were from the north and east. They must have been very strong and violent to transport such great boulders of quartz.

The gold is coarse, and appears to be distributed throughout the mass of the drift from the surface to the bed-rock; it is most abundant at the bottom, but the drift "*pays*" throughout. The gold is not uniformly distributed, but the amount in the different claims is unequal. One of the claims yielded $48,000 in five months. This was worked by nine men night and day, at an expense of $13,000, leaving a clear profit of $35,000. The usual yield is from six to eight dollars a day (ten hours) to each man, but some claims pay from twenty to thirty. The heaviest lump of gold which has been taken out at the Bluffs weighed four pounds.

PLACER MINING BY THE HYDRAULIC METHOD, MICHIGAN CITY.

All this drift is washed by what is called the "*hydraulic method*," an improvement in the art of placer mining and washing which originated among the miners of California, and which enables them to mine and wash nearly ten tons of earth where, under the old methods, they could scarcely wash one.

This process, so new to all but Californians, is well exhibited at Michigan City, and will be briefly described.

The annexed engraving is from a daguerreotype of one of the claims, and shows their general appearance. On one side we see the bank, or bluff, formed by the drift, which has not been disturbed. The top of this bank is the general level of the surface, and was once covered by pine trees, as shown by the stumps and the trees in the distance.

The frame, or staging, elevated above the surface, is a flume, or open conduit, for the water, and is *highest* in the back-ground, and the water flows towards the bluff, although in the picture the descent appears to be in the other direction. At the end of this sluice a barrel is placed to receive the water, and a long hose-pipe of leather is attached to its bottom, and extends down along a favorable part of the bank to the level of the bed-rock below. In the engraving the bed-rock is not seen, being completely covered by the large boulders of quartz that have been excavated from the bank and washed. The bank is not attacked by pickaxe and shovel, but a powerful jet of water, delivered through the hose from the reservoir above, is thrown against its base. The earth is soon washed away, and the overhanging mass of drift of earth and loose boulders falls to the ground. As rapidly as the finer portions are removed by the water, the loose stones and boulders are thrown back out of the way, while the smaller fragments, together with the sand, clay, and gold, are carried by the water into a long drain, or sluice-way, where the gold is collected. The operation is thus a continuous one, and the earth is not handled or transported except by the water. The only labor necessary is to remove the stones from the foot of the bluff as rapidly as they are washed. The whole operation may be more readily understood by the inspection of a sectional view of the claim, showing the bank of drift and the

IDEAL SECTION OF A MINING CLAIM, MICHIGAN CITY

underlying bed-rock of slate. A space for the escape of the water and earth is also shown under the heap of stones thrown back of the base of the bank; but the sluice-ways are generally much larger, and in large claims are constructed at great cost, even by tunnelling through solid rock in order to secure the proper descent. The entrance or opening to the sluices is secured by a grating of strong timbers, so that no large boulders can enter.

The operation of *sluicing* is another striking and important feature in the art of mining, as practised in California. Earth, gravel, and stones are washed by hundreds of tons in a short space of time without being handled. The sluice is a long channel or race-way to conduct the water or gravel, and is constructed either in the surface of the bed-rock by excavating, or made of boards. The former is known as the *ground-sluice*, and the latter as the *board-sluice*. A

board-sluice is generally twelve or fifteen inches in width, and from eight to ten inches deep, and is made in convenient lengths, so that one can be added to another until a length of two or three hundred feet or more is obtained. False bottoms of boards pierced with holes, or a series of raised cleats, are placed in the bottom of the sluice, and are intended to receive and retain the gold, while the stones and gravel are washed away. Long bars, or a grating with the spaces parallel with the sluice, are, however, generally preferred to the cross cleats or holes. The fall or rate of descent of the sluice is varied according to circumstances, being arranged to suit the size of the gold and the nature of the drift. One or two feet in a rod is a common inclination, and with a good supply of water is sufficient to cause stones two or three inches in diameter to roll from one end of the sluice to the other.

The earth, stones, and gold, as they enter these sluices with the water, are all mingled together, but the current soon effects a separation; the lighter portions are swept on in advance and the gold remains behind and moves slowly forward until it drops down between the cleats or bars. The larger stones and coarse gravel are swept on by the current, and after traversing the whole length of the sluice are thrown out at the lower end. The operation, as in the case of washing down the bank, is a continuous one, and requires little labor or attention, except to keep the sluice from clogging. This is done by one or two men, who walk up and down and throw out the large stones with forks.

The water for these operations at such a height above the river, and for the elevated placers or "dry diggings" generally, is brought in aqueducts from the sources of the streams many miles distant in the mountains. The water at Michigan City is supplied by the El Dorado Company's aqueduct, at this time over ten miles in length, but soon to be extended so as to reach other sources of water. After traversing the aqueduct, the water is received into a reservoir above the level of the claims, and from thence distributed to the consumers. It is sold by the inch, being delivered from a horizontal aperture one inch high and twenty-four inches long. This opening is at the side of a box twenty-four inches square and six inches deep, and is opened or shut by a slide. This box is kept full of water by making a slight dam on the sides of the ditch coming from the reservoir, and the stream is thus delivered under a constant pressure of six inches. The opening is graduated to half inches, and for each inch of water the miner pays fifty cents for each day of ten hours; but in the summer, or dry season, it is worth seventy-five cents.

MICHIGAN CITY TO NEVADA AND GRASS VALLEY.

August 15.—*Michigan City to Iowa Hill.*—On leaving Michigan City we rode back for several miles over the road by which we came, and then turned off to cross over the divide to the valley of the North Fork. Several miles from the river, serpentine was observed outcropping in slaty masses along the trail. The surface was also strewn with great numbers of spherical or globular masses, which had been liberated by the weathering of the rock. In this respect, and in its lithological characters, the rock greatly resembles the serpentine of Fort Point, at the Golden Gate. The rock at this place attains a great development, and forms a series of knob-like hills that are bare and barren, and look like the Bare Hills near Baltimore, Maryland. These bare tracts in the midst of a wooded region are familiarly known as *Brimstone Plains.*

We at length reached the margin of the divide above the North Fork, and looked off into the chasm of the river. The rapid, but to us silent, current was winding about, over 2,000 feet

below. The south banks at this point are nearly vertical, and 2,800 feet high. A fine view of the distant ridges of the Sierra was here presented to us. We were on Wisconsin Hill, now being settled upon by agriculturists.

Iowa Hill, Placer county, to Nevada.[1]—A thick deposit of drift is found at Nevada, resting upon a bed-rock of gray granite. This granite, as exposed by the mining operations, is very much decomposed and softened to a great depth, so that in places it may be removed with the pick or shovel. These softened parts, however, contain hard, globular masses, from one or two to over eight and ten feet in diameter. They look like great boulders, and lie thickly together along the course of the little stream. Wherever the auriferous drift is removed the surface of the granite is found to be very uneven, a condition which necessarily results from the manner in which the rock decomposes, and not from abrasion or denudation.

A vast quantity of earth has been washed here by the hydraulic method. One of the principal claims is owned by Mr. Laird, formerly of Georgia, who has made an extensive excavation backwards in the side of a hill formed of the drift. In washing this earth, the ground-sluice has been extensively used. They are cut in the surface of the granite and converge from the base of different parts of the bluff until they all unite and deliver the water into a board-sluice below. These ground-sluices are said to catch and retain the gold more effectually than those made of boards. The gold is, however, not so readily obtained or "*cleaned up*" from them. The operations in Nature—the concentration of gold in the beds of streams, from a wide area—is thus imitated by these ground-sluices.

The gold of Coyote Lead is generally in fine scales, and is poor in quality. It is said that it is sometimes sent to the southern mines to be mixed with better gold before offering it for sale.

Water was first brought to the Nevada Hills by the Rock Creek Ditch. This was seven miles in length, cost about $14,000, and yielded, from the sale of water, $30,000 in the first two months. Water was sold several times over, or, rather, it was used by several parties in succession, until, from the quantity of fine slime in suspension, it became as thick as pudding, and would no longer run. For a supply of eight inches, the first parties paid two ounces a day, the second twenty-four dollars, the third one ounce, and so on down to four dollars. The aqueduct was afterwards sold for about three times its original cost, and has since paid fair dividends, even for California.[2] Water is now sold for fifty cents an inch. The aqueduct of the Deer Creek Company is said to have cost $25,000, and to have paid all the expenses of construction in the first three months.

At Grass Valley I had the opportunity of visiting several of the principal quartz mines and mills for the extraction of the gold. These are located along Boston Ravine, the valley of a small stream ; but, with one or two exceptions, the quartz is mined at a distance of one or two miles, and is carted to the mills. An interesting establishment and mine, on a moderate scale, is held by the Empire Company, chiefly composed of gentlemen from New York. Their mill is about a quarter of a mile from the town, and three-quarters of a mile from the mine on "Ophir Hill."

The rocks between the mill and the mine are not well exposed to view, being chiefly covered by soil and a layer of drift. Neither are they seen distinctly upon the surface at the mine, but on descending the shaft for seventy-five or one hundred feet, they are found to consist of a hard greenstone or trap. In some places along the "*ledge*," or vein of quartz, it is fissile and slaty. The ledge appears to trend north 10° to 30° west, and dips westwardly. Its thickness varies

[1] The notes for this part of the trip were all lost.

[2] I had these facts from a gentleman who was formerly engaged in mining near Nevada.

from three inches to a foot or more, and in some parts of the mine several narrow veins combine and form a thickness of eighteen inches or two feet. This quartz is charged with veins of white iron pyrites bearing gold. An engine of fifteen or twenty-horse power drains the mine by a lift-pump, and raises the ore.

It is difficult to find a mass of the quartz in which gold can be seen by the unassisted eye; but on placing a lump of the pyrites in nitric acid for a short time, so as to partly dissolve it, gold becomes visible in numerous small points. A panful of the partly decomposed vein, near the surface, gives a good show of gold on being washed. When the quartz arrives at the mill, it is piled in heaps and roasted, and then passed through the stamps, of which there are sixteen; the fine powder passes with a current of water, first over blankets spread out in the shallow troughs, and then through a long and slowly-revolving cylinder, partitioned off by cleats, and holding mercury, known as Cram's cylinder. It is then received into a Blaisdell's pan—a large iron pan holding mercury and cannon balls—and kept in motion. Nearly three-quarters of all the gold is caught upon the blankets. These are ordinary blue blankets, and when they are taken out to be washed they present a most beautiful appearance, being covered with a layer of glittering particles of gold. They are wrung out once every hour, into a large tub of water. The gold thus obtained is mixed with a portion of pyrites, and is subjected to amalgamation. This operation is performed weekly, and enormous ingots of gold are taken to the express offices every Saturday night.

The Helvetia and Lafayette Mining Company is organized with a capital stock of $600,000, in shares of $100 each. They have fine buildings and machinery, and a bank of eighteen stamps of great weight, and it is said that eighteen tons of the quartz can be crushed by nine of the stamps in twenty-four hours. The vein occurs in connexion with trappean rock, and trends nearly east and west, dipping a little east of north. A ridge of brecciated quartz rock crops out in the low ground west of the workings, and has a trend nearly north and south. It is, perhaps, at the side of the intrusive rock.

The specimens of auriferous quartz from this mine are exceedingly beautiful. The quartz is compact and milk-white, and contains implanted filaments and thin sheets of gold completely isolated from pyrites. Some of the specimens are exceedingly rich, and their remarkable solidity and freedom from the stains produced by the decomposition of pyrites, make them particularly suitable for cutting into ornamental stones. Pyrites is found in the quartz, and sometimes in cellular nodules, or lines cavities which contain gold. The wall of the vein, in some places, has a peculiar bluish-green color, and a layer of breccia is found. This consists of fragments of a silicious deposition, very compact, breaking with a conchoidal fracture, and yet without the brilliant vitreous lustre of quartz. It is deposited in layers of grayish-blue and white, and is hydrous. It is probably allied to *cacholong*, a variety of the species opal. It is said that $12,000 worth of gold was obtained from one hundred and thirty tons of the crushed quartz and earth of the upper or decomposed parts of the vein. This was crushed by nine stamps in eight days. Seven hundred dollars' worth was once obtained from three and a half tons, being at the rate of $200 per ton. It is evident, from the appearance of the quartz, that the compact, undecomposed portions will not give such a great yield.

The Gold Hill mine is probably the most extensive at Grass Valley, and is under the superintendence of Mr. Mellville Atwood. The entrance to the mine is at the base of the hill bordering the creek, and it is connected with the works for crushing and washing by a tram-road about nine hundred feet in length. The tunnel leading to the drifts upon the veins is

about five hundred feet in length. The rock is compact greenstone, and is traversed in several directions by veins. The main lode dips at an angle of twenty-two degrees, and is stoped from the level of the tunnel, or adit, to the surface. There are several other veins which are not worked out to such an extent. One of the veins is only three or four inches wide, and is open along the centre, the quartz being deposited on each wall, so that the crystals on the opposing surfaces interlock. It is a good example of a true fissure vein. The color of the quartz, which is peculiarly stained by oxide of iron, and the character of the crystals, conforms exactly with specimens which I obtained in San Francisco, which were said to be from Grass Valley. These consisted chiefly of broad plates partly imbedded in quartz, or supported between the ends of the crystals. This, I was assured, is the character of the specimens obtained from the vein. The quartz veins of this locality do not appear to be very highly charged with pyrites, and yet they are stained by iron as if from its decomposition. Pyrites appears to exist in the wall-rock in considerable quantities.

The machinery for crushing and washing the quartz is on a great scale, and has been erected at great expense. The crushers and stamps are driven by a powerful condensing engine from the establishment of James Watt & Co. There are three large tubular boilers set very beautifully, without brick-work. The crushing apparatus consists of two sets of Cornish crushers, twenty-six inches in diameter, and twelve stamps. It is the intention to increase the number of stamps to twenty-four.

The mine of the Rocky Bar Mining Company is upon Massachusetts Hill. Several shafts have been sunk upon the vein, from twenty to fifty feet deep, until water was reached. It is not now worked, but preparations are making to sink an engine shaft to intersect the vein at a depth of 110 feet. The vein is said to dip towards the northeast at an angle of thirty-five or forty degrees. The quartz which has been removed is reported to have yielded about sixty dollars to the ton.

There are many other interesting mines and crushing mills at Grass Valley, but they could not be visited during the short stay made in the place.

GRASS VALLEY TO COLOMA.

Grass Valley to Auburn.—We travelled over a rolling, uneven country, and crossed many small creeks. The rocks are covered by drift and soil, which sustains a growth of oaks, pines, and the peculiar shrub called *mancinita.* A few miles before reaching Auburn we found the outcropping edges of argillaceous and talcose slates, and they form the bed-rock at Auburn. The surface of this foundation of rock is very irregular and rough, but is made smooth in places by a thin layer of auriferous drift, from six inches to two or three feet in thickness. These elevated flats are of considerable extent, and have been completely dug over by miners. The drift is much rounded, and is not very coarse, but large masses of the subjacent slates are found with it. A considerable part of the gold is in coarse lumps, and masses weighing from ten to eighty ounces are common.

Auburn to Coloma.—The prevailing formations from Auburn to the crossing of the North Fork of the American are clay slates and talcose slates, standing nearly on edge, and traversed by intruded dykes of basaltic or trappean rock. The rock, at the crossing, is a fine-grained syenite, cleaving like trap-rock. It appears to be a dyke of but slight thickness, and the slates are seen again a short distance beyond. We passed upon a fine-grained syenitic granite about

one mile before reaching Smith's house on the river. Trappean intrusions adjoin the granite abruptly, and quartz is abundant along the junction.

Coloma.—The hills along the South Fork of the American River, at Coloma, are not precipitous, but are rounded, and the valley has considerable width, so that many wide bars, or side flats, are formed. These consist of river-drift, sand, and gravel, and it is all auriferous. Much gold is obtained from the projecting points or headlands about which the river turns in its winding course. These points are formed of granite, and the gold is washed out of the overlying drift by the miners, as at Nevada and elsewhere. The ground-sluices are made use of here also.

This is the point at which the gold was first discovered in the race of Sutter's saw-mill. This mill is still standing, although going rapidly to decay and ruin. It is said that it has recently been purchased with the intention of manufacturing walking-canes from its timbers.

It is claimed that the piece of gold first found is still in this place, and in the possession of Peter Weimar. It is a very pretty, flattened lump, about an inch long, and five-eighths broad. The claim that this is the *first* fragment found is, however, disputed.

The river is crossed at this place by a long wooden bridge. The current is rapid and very muddy. An immense quantity of fine earth must be constantly transported by this and the many other rivers of the mining region to the delta of the Sacramento and San Joaquin, and even further down into the bay. All the streams from the mining region are made thick with the tailings of the thousand sluices that drain into them.

COLOMA TO GEORGETOWN.

At Irish Creek, about three miles from Sonora, the slate is again seen in distinct outcrops, trending from N. 32° to N. 40° W., with an easterly dip of 70° or 80°. It is a compact, fine-grained clay slate, like roofing slate, and is traversed by many thin and parallel intrusions of trappean rock. These are dykes, with a width of from six to ten and twenty feet. The cañon or ravine of the creek is narrow, and conforms in its direction to the trend of the slates. The outcrops of the dykes are chiefly confined to the bed of the creek. These dykes, together with the slates, are traversed by seams and veins of quartz containing pyrites, and many large cubes of this mineral are found in the slates. No well defined vein of auriferous pyrites was observed, but one has been worked in the vicinity, as shown by heaps of refuse and a shed, under which one of Blaisdell's "coffee-mill" crushers was placed. The beautiful octahedral and dendritic crystals which I purchased in San Francisco were obtained at some point along this creek.

At Kelsey's, several miles beyond, the slates are not so much like roofing slates, but are more talcose or magnesian, and include veins or beds of auriferous quartz, trending parallel with the stratification. A vein which has been prospected near the town is three feet wide, and consists of intercalations of quartz in lenticular masses, with thin films of the slates. The vein thus appears to be subdivided by thin layers of the slate.

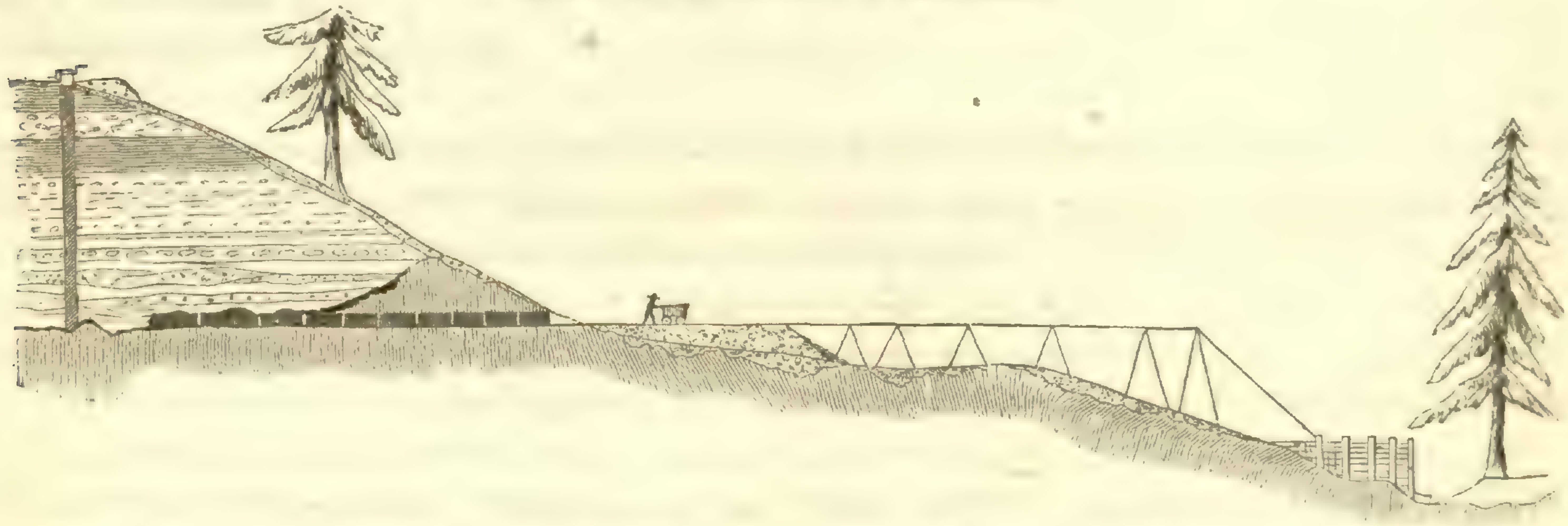
Between Kelsey's and Georgetown there are many interesting mining localities; among them, Spanish flats, where the alluvial drift is very rich.

Georgetown.—This beautifully situated mining town is about N.N.E. of Coloma, and 2,500 feet above the sea. It is regularly laid out, with wide streets, and already has its church and theatre. The underlying rocks are argillaceous and talcose slates of a light color, and in very regular, thin, and flat laminæ.

The mining operations are chiefly at Mameluke Hill, in or under a deep deposit of drift or

alluvium. The slates crop out along a ravine, but the top of the hill is formed of deposits, which reach a thickness of 200 feet or more. They rest upon a basin-like depression in the bed-rock, and the gold-bearing layer is at the bottom. In order to reach this, tunnels are cut in from the side of the hill, at such a distance below the summit that the lowest part of the basin will be intersected. To do this, it is necessary to cut through the outer or projecting rim of slate rock, and some of the tunnels are thus of great length and very costly.

SECTION OF THE HILL-SIDE AT GEORGETOWN.



The relative positions of the drift and the slates, and the method of mining, will be understood from the section. A "prospecting" shaft is first sunk from the surface of the bed-rock, and the earth tested. If the result is favorable, a tunnel is commenced on a level with the bottom of the shaft, or at a lower point, and carried in so as to intersect the shaft, or so as to strike the "pay-dirt" at a favorable point. The auriferous earth is then removed in all directions, and sent out of the mine by cars on a tram-road, and emptied down a slope or guide of boards into a large bin made to receive it. From this it is taken and washed in a board-sluice. About two feet of the earth and gravel next the slates, and even the upper edges of the slates to a depth of a foot or more, are removed, and the roof is supported by timbers precisely as in a coal mine. The whole operation of mining is very similar to that of beds of coal, where they occur above the level of streams, and are nearly horizontal, as at Pittsburg and other places.

The claim of the Mameluke Tunnel Company is opened by a cutting of at least 300 feet in length through the slates before the gold-bearing earth is reached. This forms a layer not over two feet in thickness, and rests immediately upon the upturned edges of the slates. It is overlaid by a firm and homogeneous deposit of clay, which is said to be eighty feet thick and without coarse materials. It has a dull ash-color, and contains a large quantity of pumice or volcanic ashes. Some of the masses, which have been removed in the course of mining, are traversed by cylindrical holes, looking like the casts of vegetation or roots that have since decayed and disappeared. In one of the specimens a perfect cast of a leaf was found. It is probable that this is a lacustrine deposit—the sediment from an ancient pond or lake that occupied a valley in the slates. What changes have been produced in the configuration of the surface of the region since that lake was drained!

It is said that the following succession of beds was found in sinking the shaft of the Bay State Tunnel Company:

	Feet.
Surface accumulations, (soil and gravel)	—
Gray argillaceous beds, with volcanic ejections, pumice, &c., ("cement")	40
Auriferous gravel, ("pay gravel")	8
Gray argillaceous beds, with pumice, (cement)	60
Auriferous gravel and clay resting on the slates	—

It would appear from this section that there was an alternation of quiet and running water. The deposition of clay and pumice was interrupted by a swift current bringing gravel and gold, and this current was probably similar to that which first spread the gold upon the uneven surface of the slates. It is probable also that the current was sudden and powerful, for if it had flowed for a long time, the clay would have been swept away before the gravel was laid down. The gravel must have accompanied the flood, and thus acted as a barrier to the denudation of the layer of clay below.

Through the kindness and attention of P. C. Currier, esq., I was permitted to examine the mine of the Washington Tunnel Company, one of the best on the hill, and was allowed to test the accuracy of some of the statements regarding the remarkable richness of the deposits of the hill by mining for a few minutes, on my own account, in one of the drifts. The surface of the bed-rock was worn perfectly smooth by abrasion, and a fine, white, talcose clay and some gravel rested upon it. With a candle in one hand and knife in the other, I picked away this earth, and threw out, one after another, beautiful water-worn lumps of gold. In ten minutes I had collected nearly an ounce.

The slate of this vicinity appears to contain many auriferous veins. Quartz in cellular veins, apparently auriferous, is visible at the entrance to the Washington Tunnel, and a short distance below the Mameluke Tunnel, a quartz vein, only a foot in width, is very rich in gold. This quartz was so much decomposed and stained by oxide of iron that it resembled the adjoining slate, and its presence was not suspected. The claim was worked as a placer deposit, but with little success. On taking out one panfull from the vein and washing it, gold became immediately visible, and nearly half an ounce was obtained. This was sharp, angular gold, mixed with the cellular quartz. The slate on each side is much stained with oxide of iron, and it is probable that undecomposed pyrites will be found lower down. The course of this little vein is nearly north and south, and its extreme richness, together with its friable and cellular condition, render it probable that it will be exceedingly profitable.[1]

There are many other rich placer deposits in the vicinity of Georgetown. At Cement Hill there are extensive excavations. The Swiftsure Tunnel is cut for one hundred and twenty feet in slate, and is four hundred feet in length. The auriferous earth is found under a thick deposit of fine clay, in which whole trees are imbedded. These are in a state of decomposition or change, and are dark-brown, looking nearly as black as coal. The hand may be thrust into them in some places, they are so soft, but in others the toughness of the fibre of the wood remains. They contain beautiful masses of iron pyrites, in crystalline crusts of great brilliancy; but these rapidly decompose on exposure. The clay differs from that at Mameluke Hill; it is nearly pure clay, with a reddish-brown or drab color, and was evidently deposited in quiet water. It is said to be thirty feet thick.

The Nevada Tunnel, an adjoining mine, is one of the most interesting in that region. It is cut through about four hundred and fifty feet of slates, and then reaches the "lead." The gold obtained in this mine differs from that found in the placers before described, being in small and regular scales, and indicating by its form that it was deposited in the bed of a river. This indication is verified by the character of the surface of the bed-rock; it is rounded and worn exactly as in the bed of a river, and, here and there, large, loose boulders are found. It is evidently the bed of an ancient river. Above this auriferous deposit we find a compact, brown clay like that

[1] It is reported that after we left this vein, the owners of the claim commenced sinking a shaft on the vein, and obtained over $60,000 before they had reached a depth of fifty feet.

at the Swiftsure Tunnel, and also containing forest trees. Above this compact clay, however, there is a "cement," or mixture of clay, with volcanic ejections similar to that at Mameluke Hill. A thin trap-dyke was observed traversing the slates.

This claim has yielded great profits to the proprietors. At one place, where the lead was first struck, one hundred ounces of gold were taken out from a space eighteen feet long and six wide. The gold lies close to the rock, and in places has penetrated between the layers of slate to the depth of a foot or more. It is enveloped in a thin layer of very firm blue clay, derived, to all appearance, from the abrasion of the slate.

The gold could be seen thickly implanted in this clay and on the surfaces of the layers of slate from six to eight inches or more below the general surface of the bed-rock. One pan of the clay was taken from one of the richest spots and washed out before me. It yielded about *six ounces*, or one hundred dollars' worth of beautiful gold, all of it in large scales. The sluice had been in operation half a day, washing out the "pay-dirt" collected by two men in the drifts. This operation is very interesting. The gold having accumulated among heavy pebbles and black-sand along the course of the sluice, is to be collected together or "cleaned up." It is accomplished by taking out the bars and turning on a greater quantity of water, thus increasing the force and velocity of the current. The supply of auriferous earth being stopped, the current of water soon becomes perfectly clear and the bottom of the sluice is distinctly visible. Stones and gravel are swept along, but a line of glittering scales of gold appears behind them, and as the gravel passes down before the stream the gold follows, increasing in quantity for every foot of its progress, until at last it forms a bar of golden grains which may be measured by the pint or pound rather than by ounces.

Mr. Currier presented me with a sample of iron pyrites which is obtained from the washings near Georgetown. It occurs in minute and very brilliant cubes all of the same size, and is abundant. I also obtained a small mass looking like lead and galena, which, on examination, proves to be a telluret of silver. [1] A crystal of Ilmenite was also presented to me.

An outcrop of serpentinoid rock is found about half a mile east of Georgetown, and it appears to form a dyke traversing the slates. Further east, a granitic rock appears, but is only visible in loose blocks. The soil at this point contains a large amount of peroxide of iron, and it is probably auriferous. There are indications of quartz veins between the granite and the serpentinoid rock.

VOLCANOVILLE.

Volcanoville is on the Middle Fork of the American River opposite Forest Hill, and is chiefly remarkable for the occurrence of a very interesting vein of auriferous quartz. This vein outcrops in Quartz Cañon, which leads into Otter Creek. The vein, in one place, is three feet thick, and trends N. 30° W., with an easterly dip of 45°. It is bounded on one side by a trappean rock with serpentine beyond, and on the other by slate. This slate is on the east side, and is traversed by many small veins or strings of quartz, which are also auriferous. The richest part of the vein is said to be covered up by earth, but gold is visible in many places in the white quartz, and on the wall where the quartz has been broken out. This wall has the usual appearance of smooth furrows called slickensides, but not produced by the attrition of the walls. A large amount of the quartz is free from gold, and would be difficult to crush. The gold is apparently very unevenly distributed, and forms isolated nests and bunches. At "Taylor's Claim," higher

[1] See Chapter XX., under *Hessite*.

up the ravine, several open cuttings have been made across the vein, and many fine "leads" are exposed. Gold can be detected in the fragments thrown out, but the best indications are the presence of considerable cellular quartz and oxide of iron. These veins are not now worked, and no machinery has been erected. The veins have furnished some very rich specimens. Bowlders and fragments of iron ore are abundant along the bed of the creek.

MORMON ISLAND.

Mormon Island is on the bank of the American River at the point where the foot-hills of the Sierra Nevada become merged into the plains of Sacramento. Mining is conducted in the bed of the stream and on the bars; but at a higher level, sixty feet above the river, the operations extend over a much greater area, being in the older drift and alluvium. The place is also interesting, geologically, for the extensive outcrop of a very superior granite which forms bluffs on each bank of the stream. This granite is highly structural; the minerals are arranged in parallel planes or layers, appearing as lines on the surface. They determine a direction of easy *rift*, or cleavage, which is favorable to the operation of quarrying and splitting the stone for building purposes. The color of the rock is a pleasing gray, not unlike that of Quincy syenite. Its trend is N. 26° E. Lenticular masses, or agglomerations of hornblende and mica, of a dark color, are found in parts of the rock, and are frequently drawn out into sheets or lines. They are like the masses seen in the granite of the summit of the Sierra Nevada at the Tejon Pass.

CONCLUDING OBSERVATIONS ON THE GEOLOGY AND THE AURIFEROUS DRIFT.

The principal geological features of the central portion of the Gold Region which was traversed, as detailed in the foregoing notes, may be briefly enumerated.

Talcose and clay slates are the prevailing rocks, and in general present a low degree of metamorphism. The color is generally light, and apparently little changed from the original tint of the sediment. More highly metamorphosed portions appear to occur in narrow belts, and to be near the lines of intrusive rocks.

The strata are, in general, upon edge, or inclined at high angles, and trend in a north-westerly direction with great uniformity, and without abrupt and local plications or disturbances of the beds. The plications into which they have been thrown are upon a magnificent scale and very regular. This formation of slates occupies the wide space between the intrusive rocks which form the axis of the Sierra Nevada and a belt of granitic rocks at the base of the slope, and at the margin of the great California plains. The slates are also traversed by erupted rocks at many intermediate points, and are thus cut up into a series of parallel bands or belts of metamorphic and intruded rocks, the former predominating. These intrusions are chiefly trap or greenstone, and a serpentinoid rock which resembles that at Fort Point, and may be considered by some as a metamorphosed sediment; but the evidences favor the conclusion that it is of igneous origin. Granite is found at Nevada and Grass Valley, and again near Coloma, and appears to be succeeded on both sides by slates; but the relations of these outcrops—whether they form one belt, or two or more—I am unable to decide without a map on which the places are laid down with accuracy.

The lower or most western outcrop, to which reference has been made, appears to form a well-defined belt of considerable length and breadth. It was crossed on the road between Sacramento and Auburn, and further south at Mormon Island, in the range of the trend. This belt is one

of the principal erupted axes of the region, and is the first rock met with on leaving the plains of the Sacramento for the interior.

The observations upon the outcrops of the granitic and metamorphic rocks along the line of the expedition, in the Valley of the San Joaquin and the Tulares, indicate that there is a succession of granitic axes, trending nearly northwest and southeast, and thus making a considerable angle with the main axis of the Sierra Nevada. These successive belts of metamorphic strata and erupted granites, and the like, pass below the more modern deposits of the great California Valley, as will be seen upon the General Map. It will probably be found that the metamorphic axes, or the lines of uplift and flexure, throughout the Sierra Nevada, trend *obliquely* to the general axis of the chain. This view is sustained by the topography of the Coast Mountains and other chains.

The next important formation is the white, crystalline limestone, which was found developed to such an extent at Columbia, Sonora, Cave City, and the vicinity. It attains a great width; is nearly vertical in its planes of structure, and appears to form a long belt trending northwesterly through Tuolumne and Calaveras counties. It probably extends much further, both north and south. It is believed to be parallel to, and conformable with, the great slate formation. At Abbey's Ferry, on the Stanislaus, it was found in connexion with mica-slate and granite. This rock is doubtless metamorphic, but as no fossils or relics of any have been found in it, it is impossible to decide upon the period to which it should be referred. It is possibly *carboniferous limestone*, this formation having been recognized in the northern part of the State, while we are yet without evidences of the presence of Silurian formations west of the great central chain of mountains.

The rock is very different from the limestone of the Tejon Pass and the Cañada de las Uvas, being more regularly stratified, and having many blue veins and layers, all trending with the beds. The Tejon limestones are compact, granular marbles, perfectly white and containing scales of graphite; the metamorphic action having been more intense than upon the limestone of the gold region.

If a line be drawn through the several known outcrops of this limestone, it will be found to extend in a northwesterly direction, and if prolonged, would intersect the slate region in the region of Coloma, Auburn, or Yankee Jim's. Limestone is not known to occur there, and it is probable that nearly opposite to Mokelumne Hill the outcrop is deflected to the east. It is at this point, or abreast of it, that the trend of the Sierra Nevada becomes greatly changed; its direction becoming nearly north and south rather than northwest and southeast. All the formations—slates, limestone, and the granite—appear to be shifted further east, and to pass behind the formations south of the American or Cosumnes Rivers. The possibility that the great limestone belt may pertain to the lower or western granitic axis between Sacramento and Auburn is worthy of consideration, but in the present state of our knowledge of the region, and the absence of accurate maps, it is impossible to arrive at any satisfactory conclusion respecting the relative positions of the formations north and south of a line drawn east and west through Carson's Pass, at the point where the change in the direction of the Sierra Nevada commences.

These formations—the erupted and metamorphic rocks—form the floor or bed-rock upon which a very different series of formations is deposited. These formations consist of the auriferous drift in its various forms, and of a more uniform and extended series of nearly horizontal strata of clays, sand, and gravel. These last are of marine origin, and probably Miocene or Pliocene Tertiary. In many parts of the region they are entirely swept away, and scarcely a vestige

remains; but at other points they are found in extensive plateaux or gently sloping table-lands bordering the rivers, which have cut their way downwards through the strata and exposed them to view. The table-like hills or mountains seen from Knight's Ferry, on the Stanislaus, and between the Mammoth Grove and the Great Cave, are examples of these deposits. In many places they are overlaid by a stratum of basaltic lava, like that at Fort Miller, on the San Joaquin. It is most probable that the principal deposits of this great series of nearly horizontal strata, flanking the Sierra Nevada in the Gold Region, are of the same age as those from which fossils were obtained further south along the Tulare valley. Marine Tertiary fossils are abundant at Chico Creek, and at other places along the eastern side of the Sacramento Valley. Indications of the Cretaceous rocks are also found.

The overflows of basaltic lava constitute an important feature in the geology of the Gold Region. They are found to overlie the auriferous drift as well as the older strata, and produce the remarkable flat-topped hills called *Table Mountains.*

There are many varieties or modifications of the auriferous drift, or, we may say, of the deposits of gold. We find:

First. A coarse, boulder-like drift, the result of great abrasion and powerful currents in a great body of water.

Second. A river-drift, or coarse alluvium, ancient and modern.

Third. Alluvial deposits on flats and over broad surfaces, not confined to river channels.

Fourth. Lacustrine deposits—at the bottoms of former ponds or lakes.

The deposits of the first class are very irregular, and differ in their lithological characters and manner of deposition at different localities. The observations were sufficient to show *that, in many cases at least, the accumulations are extremely local,* and that they were not transported from a great distance. The great deposit of quartz boulders, and sand of the same material, at Michigan City, is regarded as an evidence of the comparatively local character of the force, or current, which deposited them; for if it had been extensive, or had flowed in a similar manner for a great distance, other rocks and gravel would have been mingled with the drift. At Forest Hill, also, the gold is found in crystals, but little water-worn or rounded; and quartz crystals are taken out with the crystalline planes scarcely scratched, but with their angles broken off, so that the effect of a current is shown. Deposits of this class contain coarse lumps and grains of gold, and are found on the high table-lands, or "divides," between the rivers, often at an elevation of over 2,500 feet above them.

The river-drift containing gold, appears under a variety of forms. It may be either coarse or fine; but is found of all ages, from the accumulations now forming in the beds of the streams, and in bars, to the deposits of rivers which formerly flowed over the surface 2,500 feet higher than now. The courses of such ancient streams are discovered by the miners, and followed by them in their underground explorations. All the peculiarities which the beds of rivers present—the water worn surfaces, pot-holes, and fine scale gold—are found in them.

The rich deposits of gold found in the thin layer of gravel and clay, spread over broad areas or "flats," are mentioned as forming a third class. They differ from the linear deposits formed by streams, and yet they appear to be the result of a continuous current passing over the surface. In many instances such deposits give evidence of having existed as a marsh or swamp, or as a low district, inundated at times by rivers, and serving as a repository for a portion of their suspended alluvium. In many of these deposits, however, the masses of gold are quite heavy, and the grains as coarse as those in the first class of deposits. It is probable that the

gold was deposited with a thick layer of drift, which was afterwards swept away, leaving the gold behind. It would appear that the drift had been re-assorted, or perhaps removed, by currents of less strength and extent than those which transported the gold.

The deposits of the fourth class, called *Lacustrine*, are found in extensive basin-shaped depressions in the surface of the metamorphic rocks. These depressions have evidently been filled with deep and quiet water, from which thick strata of clay, fine sand, and volcanic ashes have been deposited upon the auriferous layer at the bottom. The deposits at Georgetown and Cement Hill are examples of this class. They are more nearly allied to the alluvial deposits of the "flats" than to either of the other forms under which the auriferous drift appears. The section of the strata at Mameluke Hill shows that the deposition of clay and volcanic ashes from the lake was interrupted, and that a layer of coarse, auriferous gravel was spread out over the surface of clay, after which the former conditions were restored. This alternation, or a series of auriferous and non-auriferous materials, stratigraphically deposited, forms a well-marked difference between the lacustrine deposits and those of the flats.

Great changes have been produced in all of these deposits by denudation and erosion during and since the elevation of the region to its present level. The old rivers changed their beds, lakes were drained, and new streams cut their way through great deposits of coarse drift, through lacustrine deposits, and across the ancient river-courses. But the action of the denuding streams has not been confined to the superficial deposits, either auriferous or Tertiary; they have eroded great valleys and cañons in the underlying rocks, both of granite, limestone, and slate; all are cut through and traversed by long valleys nearly transverse to the trend of the rocks. These valleys of erosion are on a most magnificent scale, and may be regarded as deep ravines in a formerly unbroken plateau or slope. Their general form is shown in the section.

RIVER CAÑON—VALLEY OF EROSION IN SLATE.

On the forks of the American River these eroded valleys are from 1,500 to 3,000 feet deep, and the traveller who desires to cross from one bank to the opposite side must wind in a zig-zag line down one side and in a similar manner up the other; traversing a distance, in most cases, of nearly three miles, while in a direct line it may be but little more than one mile from one bank to the other. All this erosion has taken place since the original deposition of the gold; and it is probable that the gold of the streams is derived from the original deposits of coarse drift rather than from the action of the rivers upon the veins, although a very considerable quantity of gold must have been liberated from the veins by their action. The great currents, or floods, which produced the drift were much more general and wide-spread in their action, and appear to have abraded the whole surface rather than mere lines or channels.

All the observations upon the auriferous deposits sustain the conclusion arrived at by Sir Roderick I. Murchison, after his explorations in the Urals—that the formation of gold is, geologically speaking, very modern; that it is one of the most recently formed metals; the rocks being probably impregnated with it after the Miocene period, and but "a short time before the

epoch when the powerful and general denudations took place which destroyed the large extinct mammalia.[1]" Although, as before observed, the relations of the auriferous drift to the older or Tertiary strata at the base of the Sierra Nevada are not yet clearly shown, it is believed that these marine strata containing Miocene fossils are free from gold. Gold is found under horizontal strata of great thickness and extent, but it will probably be found that these deposits are comparatively modern; more recent than the period of the Mammoth and Mastodon.

It is also the opinion of the distinguished geologist, whose name has been mentioned, that it is probable that the impregnation of the Urals with gold took place when the highest peaks of the chain were thrown up and its present watershed established, and when the syenitic granites and other comparatively recent igneous rocks were erupted along its eastern slopes.[2] It is probable that the impregnation of the rocks of the Sierra Nevada was similarly produced. We find great lines of erupted syenitic granite and dykes of greenstone and serpentine traversing the auriferous districts. It seems most probable that the appearance of the gold was nearly coincident with that mighty convulsion which resulted in the elevation of a great part of the Coast Mountains and the drainage of the whole western base of the Sierra Nevada, until that time covered by the waves of a Post-Tertiary sea.

At such a time denudation by floods would be most active; and, until the newly risen continent had attained its permanent elevation, the streams and rivers must have been constantly changing their channels; lakes must have been formed, and then drained, and a series of effects produced corresponding to those we now witness over the whole region.

There is no doubt of the Post-Tertiary, or at least the Post-Pliocene, age of the Coast Mountains. We find them composed in great part of Tertiary strata, thrown into great wave-like flexures, with here and there a granitic axis of limited extent, but with serpentine abundant. In the auriferous regions a similar serpentine abounds, and has in all cases the aspect of an intrusive rock. The movements which attended the uplift and plication of the Coast Mountains must have affected the whole western slope of the Sierra Nevada. I am thus led to the conclusion that the impregnation of the rocks with gold and the formation of the Coast Mountains were nearly synchronous.

[1] Siluria.

[2] Russia in Europe and the Urals.

CHAPTER XIX.

BUILDING MATERIALS.—COAL.—LIGNITE.—BITUMEN.

Distribution of building materials.—Granite.—At the mouth of the Gila.—Bernardino pass.—Warner's pass.—Cajon pass.—Tejon pass and Cañada de las Uvas.—Tejon to Fort Miller.—Fort Miller.—Fort Miller to Livermore's pass.—Granite at San Francisco.—Quarries at Monterey and Punta de los Reyes.—Mormon island.—Sandstone of San Francisco and its vicinity.—Adaptation as a building material.—Sandstone of Benicia, Fort Ross, and Mokelumne hill.—Limestone.—Limestone in the vicinity of San Francisco.—At the Tejon and Cañada de las Uvas.—Cajon and San Bernardino.—Bitumen.—Tar springs of Los Angeles.—Bituminous shales.—Uses of the bitumen.—Coal.—Absence of coal of carboniferous age.—Bellingham bay coal.—Extent of the beds and quality of the coal.—Section.—Synchronism of the strata with those of San Francisco.—Coal from Vancouver's island.—Use of the coal on the steamer Active.—Cowlitz coal.—Lignite near San Francisco.

BUILDING MATERIALS.

The following are brief notes upon the principal building-stones and their distribution along the line of the survey. In the event of the construction of a railroad over any part of the line which has been explored, abundance of suitable stone will be found in the mountains or in the ridges at the sides of the passes, but none can be obtained on the plains; for those parts of the line it must be transported from the nearest and most available points. These will be enumerated in their order of succession from the mouth of the Gila to San Francisco.

GRANITE.

Junction of the Gila and the Colorado Rivers—Fort Yuma.—This is an important point upon the line, and requires a supply of stone to form abutments for a bridge. It seems almost as if this want had been foreseen, for an isolated granite knob rises up from the surface of the Desert at this place, and is the only locality of building-stone within a circuit of many miles. It is at the point where it is most needed, and, indeed, the abutments for a bridge seem already formed. The rock contains a large amount of feldspar, and is porphyritic; it is firm and durable, and suitable for masonry. Stone can be taken from this point to any part of the Colorado Desert; and it can also be obtained at Pilot Knob, seven miles further west, on the line.

Bernardino or San Gorgoño Pass.—The mountains on both sides of this Pass are granitic, and will afford abundance of stone suitable for bridges or abutments. The rocks do not crop out along the roadway or open part of the Pass, and must be obtained from either side. The rocks of San Gorgoño Mountain are laminated and slaty, being chiefly gneiss intercalated with white limestone. These rocks are chiefly on the slope towards the Desert, further west, or at the summit and beyond; they are more compact and solid, and there is little doubt that good granite can be obtained from some of the numerous cañons which extend towards the centre of the mountain. It is abundant on the north side of the Pass on the flanks of San Bernardino Mountain.

This would be one of the principal points for obtaining granite to build bridges or abutments, if such are found necessary in the northern parts of the Desert. Granite and gneiss could also

be procured from the outlying ridges of the Peninsula Mountains on the west side of the Desert.

Warner's Pass.—On the summit of Warner's Pass and in the vicinity of the thermal springs, Agua Caliente, there is an abundance of a beautiful granite in large, solid, gray blocks, many feet in diameter. It extends along the crest of the mountains for many miles, and can be obtained near Santa Isabel. Beyond this, to San Diego, granite and gneiss are abundant, and are succeeded by sandstone near the coast.

Cajon Pass.—Granite, gneiss, and white limestone are abundant and accessible in this Pass. Beyond, along the slope of the Great Basin, or along the southern base of the Bernardino Mountains, stone can be obtained from the lower ridges.

Tejon Pass and the Cañada de las Uvas.—Good granite is abundant near Lake Elizabeth on the route to the Cañada de las Uvas, but in the Pass, there are no convenient outcrops until the summit is reached. Sandstone can, however, be obtained on either side. From the summit to the Tulare Plains, granite, gneiss, and limestone are found on each side. The granitic rocks are found throughout the extent of the Tejon Pass, and again between the valley or *Tejon* and the slope of the Tulare Valley. Limestone and quartz rock are abundant on the east side near the surface of the Basin, and limestone is also found in the ridges of the west side of the Pass near the entrance to Tejon Ravine.

From the Tejon to Moore's Creek, or its vicinity, granite is not found on the line of the Expedition, and the Tertiary sandstones are too friable and unconsolidated to be relied on for building purposes. From Moore's Creek to Fort Miller, the lower ridges of the mountains are chiefly metamorphic and magnesian slates, not well adapted to purposes of construction.

Fort Miller, on the San Joaquin river.—Excellent granite is found, in unlimited quantities, near this post. It occurs not only in place, but in large, loose blocks along the stream. At one of the outcrops, a large quantity of stone has been removed in constructing a road, and its quality is thus well exhibited. The locality is so near the plain of the San Joaquin, that in the event of the construction of a railroad over it the granite could be conveniently obtained for abutments and bridges.

Beyond Fort Miller to Livermore's Pass, the foot-hills or ridges of the Sierra must be resorted to for granite. It occurs on the Fresno River, near to the plain, but beyond that place the rocks of the lower ridges are believed to be principally slates, and not suited to purposes of construction. Granite has not yet been found in the Coast Mountains between the lower end of the San Joaquin River and San Francisco.

San Francisco.—The city of San Francisco has been chiefly supplied with granite from the Chinese quarries at Macao and Hong Kong. In 1854, however, it was found that an unlimited supply, of a good quality, could be obtained from Point Pinos, Monterey, and from Point Reyes, on the coast, about twenty miles north of the city. Quarries were opened at both places, and it was found that large blocks could be most readily obtained at Monterey. A large quantity of stone ("dimension stone") was quarried there and shipped to San Francisco, to be used in the construction of the fortifications at Fort Point.

The granite does not contain much hornblende, but small crystals of black mica are disseminated through it, and give it a pleasing gray color. It is also porphyritic, containing large isolated crystals of feldspar. In texture it is well adapted to building purposes, being fine-grained, and breaking into blocks of any desired size. The outer portions of the rock were slightly rusty, or made yellow by weathering, but on breaking out blocks below the surface,

the whole appearance was changed, and clean, sound stone could be procured. This rock has also been used in small cubical blocks for paving the streets. The rock at Point Reyes is darker and more hard than that of Monterey, and contains a little hornblende.

The quarries are directly upon the seashore, and the stone can be placed on shipboard without previous land transportation. Their proximity to San Francisco, and the facility with which the stone can be obtained, renders them exceedingly valuable as a source of building material.

Mormon Island.—American River.—A very beautiful and compact syenitic granite is found at Mormon Island. It has been used in the construction of buildings in Sacramento. It is, however, twenty miles from water transportation, and, consequently, cannot be obtained with economy.

SANDSTONE.

The San Francisco sandstone is used to a considerable extent for buildings in the city, and for foundations where "dimension stone" are not required. The rock, however, is not obtained from the outcrops in the city; it is more favorably exposed for quarrying at other points around the head-lands of the bay and on the islands. Quarries have been opened at Yerba Buena Island, opposite the city, at Angel Island, and at the State's Prison. The latter quarry is most extensively worked, and it supplies a large amount of dimension stone.

The color of this sandstone varies at the different localities, and its weathered portions are much rusted and stained by the formation of peroxide of iron. In general, the color of the undecomposed, or not oxidized, portions is a dark, bluish-green, very much like that of some of the trappean rocks. Wherever it is quarried into it is found that the outer or exposed portions have become *rusted* and softened to a great depth, and that it is traversed by innumerable fissures like cleavage planes, which prevent large and solid rectangular blocks from being obtained. It has been found necessary to excavate below this thick and partly decomposed covering, and even to quarry below tide-water, in order to procure stone of good size and uniform in texture and color. The quality of the stone below tide is superior to that above, in every respect, and it appears to be the only portion of the stone in its normal or unchanged condition. From the fact that this sandstone has undergone a change of color, and is partly decomposed to a great depth, even to the level of tide water in most places, we are led to expect that the unchanged portions, when exposed to similar conditions of air and moisture, will undergo a corresponding change of texture. It is, however, impossible to say how long the stone may remain in a wall without undergoing a perceptible change. It would doubtless be more durable in a dry wall than in one kept moist by the absorption of moisture from adjoining banks of earth.

This sandstone contains a large per centage of oxide of iron, which probably exists as a protoxide in the undecomposed portions, and as the sesquioxide in those portions which have been exposed to the weather; the change thus producing the brown or drab color seen at all of the outcrops. The rock, in some places, also contains very minute grains of sulphuret of iron, but this is not a common ingredient. Carbonate of lime exists in all of the specimens that I have examined, and the rock is, in fact, a calcareous sandstone.

It is a very firm and dense rock, and is very strong and tough. At first sight it is easily mistaken for trap, especially at the weathered outcrops, where the stratification is not distinctly exposed.

The stone obtained from the State's Prison quarry is lighter in its color than that from Yerba

Buena. When first taken out it is readily cut into any desired form, but hardens on exposure to the air or after drying, but does not become too hard to work. It is necessarily much more expensive to work a quarry downwards, below tide, as in this case, than to split out blocks from a bluff above the general surface of the ground. The sandstone also lies in beds, which are of variable thickness, rendering it difficult to procure dimension stone of uniform size.

Benicia.—A large quantity of sandstone of a rusted or buff color is obtained at Benicia, and sent down to San Francisco. It appears to be identical in its lithological characters and age with the partly decomposed stone of San Francisco Bay. Its principal recommendation, as a building material, is its cheapness and the facility with which it can be cut into blocks. It is very soft, as compared with the unchanged rock, and in many cases the angles of the stone can be crumbled off by the fingers. Its quality is far inferior to that of the undecomposed blue stone, it being much more friable and liable to wear away by the action of the weather.

Fort Ross.—A light-colored gray sandstone is obtained on the coast at Fort Ross and other places. That from Fort Ross contains considerable carbonate of lime, and is friable. It is, however, more compact, and has a finer grain than the Benicia stone, and also has the appearance of a more durable material. It is easily worked, and takes a good polish or a very smooth surface on being rubbed down with fine sand.

A peculiar building material is obtained from Mokelumne Hill, and is used to a slight extent in San Francisco. It is a very light and porous rock of sedimentary origin, consisting chiefly of fine volcanic sand and light ashes, with the fragments and dust of pumice-stone. The color varies from a delicate pink to light-yellow, and is very pleasing. The stone, although light and soft, and easily cut by a knife or saw, appears to be tough and strong. It is very easily worked or cut into any shape, but cannot be regarded as a valuable building material, except, perhaps, for temporary structures not requiring great strength.

LIMESTONE.

The State of California is well supplied with this material, and several localities are within convenient distances of San Francisco. It is found north of the city, on the shores of Tomales Bay, Marin county, and on the south, near Santa Cruz. It is also found near the quicksilver mine at New Almaden, and on the western side of the San Juan Mountain, near the road to Monterey. According to Rev. Walter Colton, it is found within ten miles of Monterey, and was used by him in the construction of the court-house.

At all these places the rock is the white, crystalline variety,[1] found associated with granite, and commonly known as "primitive" or metamorphic limestone. A considerable quantity of lime is made, both at Tomales and Santa Cruz, and both places being upon the coast it is readily transported to the city.

Tejon Pass.—Abundance of pure white limestone was found in the Tejon Pass, on both sides of the summit. That on the western side is at the entrance to the side ravine, leading to Taheechaypah prairie. On the east, it comes to the surface in a series of extended ridges, near the slope of the Great Basin. In some parts of these ridges the rock is snow-white and beautifully even in its grain, and it might appropriately be called statuary marble.

Cañada de las Uvas.—The position and peculiarities of the numerous ridges of limestone in this place have already been noticed in Chapter XV. The outcrops are also indicated in the

[1] A dark, reddish-brown limestone also occurs on the shores of Tomales Bay, but the locality was not visited. A specimen of the rock in the collection is traversed with white veins, and is compact and fine-grained. It might be called *marble*.

small geological map of the Pass and in the sections. This rock will make excellent lime, but there is not a great abundance of fuel in the vicinity.

Cajon Pass.—A large number of boulders and fragments of white limestone were seen in the higher parts of the Cajon Pass, and a considerable body of the rock undoubtedly exists, *in situ*, in some of the adjacent ridges.

San Bernardino.—This settlement is well supplied with limestone from the mountains southeast of the city. I had no opportunity to visit the locality.

San Bernardino or San Gorgoño Pass.—Limestone is abundant in almost every point that extends outwards from San Gorgoño Mountain towards the west. It is also found in the lower ridges along the Desert, near the Pass.

BITUMEN.

There are numerous places in the Coast Mountains, south of San Francisco, where bitumen exudes from the ground and spreads in great quantities over the surface. These places are known as *Tar Springs*, and are most numerous in the vicinity of Los Angeles. It is also common to meet with large quantities of this material floating on the Pacific, west of Los Angeles, and northward towards Point Conception. I have seen it, when passing this point, floating about in large black sheets and masses. These masses are probably the product of submarine springs; or they may be floated down by small streams from the interior. I am informed by Lieutenant W. P. Trowbridge, of the United States Engineer Corps, that the channel between Santa Barbara and the Islands is sometimes covered with a film of mineral oil, giving the beautiful prismatic hues that are produced when oil is poured on water.

Springs at Los Angeles.[1]—Some of the springs that I examined near Los Angeles were mere overflows of bitumen, or asphalt, from a small aperture, around which it had spread out so as to cover a circular space about thirty feet in diameter. This had hardened by exposure, and was covered and mingled with dust and sand, which quickly adheres to the clean and fluid surfaces. The outer portions were as hard as a pavement, and the mass was highest towards the centre, where it was soft and fluid like melted pitch. It was thus evident that all the hard portions had risen in a fluid state, and by the heat of the sun had been gradually spread out over the surface. Being constantly exposed to dust, which had become thoroughly incorporated with the asphalt, it had acquired the consistency and hardness of an artificial mixture. This spring is about seven miles from Los Angeles, on the banks of a small brook, and is underlaid by bituminous shales. Bituminous shales are also exposed at the shores of San Pedro, near the base of the vertical bluffs of the sedimentary formations of the slope. Rounded masses of silicious strata, charged with bitumen, are cast up by the waves, and are probably broken from submarine outcrops.

[1] I translate the following notice of the "Tar Springs" from the work of De Mofras: (vol. ii, p. 337; Paris, 1844).

"Two leagues to the southeast of Los Angeles there are four great sources of asphaltum, situated on a level with the earth in a vast prairie. These springs open in the middle of little pools of cold water, while the bitumen possesses a higher temperature. This water has a mineral taste which, however, does not prevent animals from drinking it. At sunrise the orifices of these springs are covered by enormous bubbles of asphaltum, often being more than a yard high, and looking like soap bubbles. According to the warmth of the air, the gas contained in the bubbles expands and bursts, producing a rather violent detonation. The inhabitants collect the solidified asphaltum and use it for covering the roofs of their houses, formed of reeds or of pieces of wood (shingles). Vessels carry this bitumen to different parts of the coast. This material, nevertheless, has the inconvenience of melting in the sun, running down from the roofs, and penetrating through the roofing. The houses that are covered with it require particular care, but small expense, since the springs are worked by any one, according to their wants."

There are several localities of bitumen in the vicinity of Los Angeles which I did not have the opportunity of examining. At one place it is said to form a large pond or lake about one quarter of a mile in diameter. This is the source from which the principal supply is obtained. The residents of Los Angeles make use of large quantities of the material for covering their buildings and for pavements. It enables them to make roofs, that are almost level, completely water-tight; and it is spread out upon them in the following manner: The asphalt is taken early in the morning, when it is cold and brittle, and broken into small fragments. It is then spread upon the roof, and the heat of the sun melts it down into one homogeneous crust. When the inclination of the roofs is great, or the asphalt is freshly applied, it runs off at the eaves, and is a source of annoyance to pedestrians. After a considerable quantity has thus run down, it is thrown up again, until, at last it becomes so much hardened that it is no longer made liquid by the sun. These roofs, when well made, are perfectly water-tight, and are very durable. The value of this material for making pavements, roofs, cements, and in the manufacture of gas and oil, cannot be lightly estimated, and it should be regarded as one of the valuable mineral productions of the State.

COAL.

The geological formation of the country examined by the Survey is not such as to indicate the existence of mineral coal of the age of the Carboniferous. The only indications of coal that were found were the bitumen springs, and the bituminous shales, of the Tertiary formations, near Los Angeles. It is *possible* that beds of compact coal exist deeper in the strata below the bituminous beds, but this can only be determined by deep and expensive boring. The probability is, that if coal does exist, it is at such a great depth that it cannot be mined to advantage, or so cheaply as fuel can be furnished from other sources.

Bellingham Bay Coal—Washington Territory.—Although this locality is far beyond the limits of the region explored by the survey, it is not deemed inappropriate to give the following facts, which were obtained in San Francisco.

Coal from this locality was in use in the city in 1854 for burning in grates and for cooking, and gave general satisfaction. It is a compact and perfectly black bituminous coal, breaking with a brilliant conchoidal surface, and, in large masses, much resembles the carboniferous coal mined at Pittsburg, Pa. It burns freely, and leaves a fine, white ash, which appears to be very abundant, but may not be present in such quantity in the better or interior parts of the vein. Through the kindness of Lieutenant W. P. Trowbridge, of the United States engineers, who has examined the region, I am able to present the following extracts from a manuscript report made by him in August, 1853.

"The coal strata exposed to view on Bellingham Bay are situated in latitude 48° 43′, and occur in a series of stratified rocks, which dip at an angle of 70° from the horizon, and strike E. 15° N. The thickness of the series being about two thousand feet." * * * * "The coal beds enter the bank at right angles to the shore-line, and rise with a gradual slope to the height of about three hundred and fifty feet, at the distance of half a mile from the shore, where they are broken in a direction oblique to that of the beds, and fall off in abrupt ledges to their original level." * * * * "From the sections it will be seen that there are ten workable seams of coal, interstratified with six or seven heavy beds of sandstone, and numerous strata of bituminous shale, slate, clay, iron-stone, and thin beds of sandstone. In two thousand feet the coal occupies about one hundred feet; the thick beds of sandstone about

seven hundred, and other rocks about twelve hundred." * * * * "The workable veins are, respectively, 20′, 6′, 6′, 12′, 25′, 5′, 5′, 18′, and 13′ feet in thickness—making an aggregate of 116 feet.

"Bellingham Bay here offers a fine harbor and good anchorage for vessels of all kinds; and by constructing a wharf a few hundred feet in length coals can be brought down from the pits in cars, and dropped into the vessels, without the employment of any other power than their own weight."

The following descriptive section is also given by Lieut. Trowbridge. The measurements are on a horizontal line; the real thickness of each stratum is therefore $\frac{94}{100}$ of that stated.

SECTION OF COAL-BEARING STRATA, BELLINGHAM BAY.

	Feet.		Feet.
1. Sandstone, (thickly bedded) about	150	21. Coal (impure)	4
2. Coal	20	22. Clay and shale	40
3. Shale	6	23. Sandstone	35
4. Argillaceous sandstone	6	24. Coal	12
5. Clay shale	10	25. Bituminous shale (probably will work into coal)	14
6. Slate filled with impressions of leaves	2	26. Coal	25
7. Clay and bituminous shale	14	27. Clay	24
8. Slate filled with impressions of leaves	4	28. Sandstone, (thickly bedded,) about	100
9. Clay	55	29. Clay	30
10. Bituminous shale	25	30. Stratified argillaceous sandstone	50
11. Bituminous shale and clay	178	31. Coal	5
12. Sandstone, (thickly bedded,) about	200	32. Clay and shales	200
13. Coal	6	33. Coal	5
14. Shales	35	34. Shales and slates	150
15. Coal	6	35. Coal	18
16. Sandstone and shale	25	36. Clay	20
17. Coal	6	37. Sandstone, (thickly bedded,) about	200
18. Clay, iron-stone, clay, and shale	145	38. Coal	13
19. Coal (impure)	4	39. Clay	15
20. Clay	40	40. Sandstone (thickly bedded.)	

It is possible that some of the many distinct beds of coal described by Lieutenant Trowbridge are not perfectly pure; they may contain seams of bituminous shale, or earthy matter, which, in the rough and unworked outcrops, might be considered as good coal. The number and thickness of the beds, as given in the section, show that the formation is very remarkable and extensive, and excites a desire to know more of the geology of the region.[1] An extended and careful survey is exceedingly desirable, not only for the geological results that may be expected, but as preliminary to the exploration of the beds.

The imprints of leaves and twigs occur in the shales of the locality; but the specimens procured by Lieutenant Trowbridge were too obscure and imperfect to permit their specific characters to be made out.

I learn from one of the officers that accompanied the United States Coast-Survey steamer Active on a recent trip to Puget Sound, (1854,) that the Bellingham Bay coal was used on the steamer a part of the voyage. The furnaces of this steamer are provided with "drop and return flues;" but notwithstanding this construction the flame from the furnaces would generally pour out of the top of the smoke-stack for ten or twenty feet. This is sufficient evidence of the existence of a very large amount of volatile matter in the coal; and it shows that the fire was not properly managed, or that the furnaces were not adapted to the peculiarities of the

[1] It is not impossible that these beds of coal are so much plicated that the same series is included more than once in the section as above given. I am assured, however, that the measurements were made with great care.

coal. This coal produced a large amount of a very fluid slag, and it was necessary to rake the fires every twenty minutes. It was regarded as inferior to the coal from Vancouver's Island, which was also used on the steamer.

The wharf at the mine on Bellingham Bay was not completed when the steamer left, and it was necessary to take the coal off to the vessel by lighters. Even these small vessels were obliged to take advantage of the tides in order to reach and leave the dock. The excavation into the hill, on the course of the coal-bed, did not extend over twenty feet; a large part of the coal at that time must, therefore, have been of very inferior quality, in consequence of long exposure to the weather and the infiltration of impurities.

A block of sandstone obtained from the vicinity of the coal-bearing strata by Lieutenant Trowbridge very much resembles, in its lithological characters, the sandstone of San Francisco and its vicinity. The color is nearly the same; and it likewise contains small disseminated scales, or films, of a dark color, very much like those seen in the sandstone from Yerba Buena and Benicia. It also contains two thin fragments of coal, the remains of coal-plants, and one round fragment looking like a rounded or water-worn mass. Two well-preserved shells of the genus Pecten are contained in the same block. The synchronism of the stratum from which this block was taken with the standstone of San Francisco is more than probable.

COAL AT VANCOUVER'S ISLAND.

Coal is obtained on Vancouver's Island from the port of Nanaimo, about eight or twelve hours run by steamer from Bellingham Bay. This coal is considered to be of better quality than that from Bellingham Bay; but it is also objected to on account of the great quantity of slag and cinder that is formed during its combustion.

I have seen this coal in use on the Active, and noticed that the amount of slag was unusually great. It ran down in streams from the grate-bars into the ash-pit, and could be drawn out into threads like glass.

It is probable that the coals from Puget Sound will require a peculiar form of furnace for their successful combustion. The abundance of the supply, and the convenient proximity of San Francisco and other ports on the Pacific, render the localities worthy of careful attention and extensive exploration.[1]

Cowlitz coal.—A coal of medium quality is obtained from the banks of the Cowlitz River, and it has been mined to some extent by parties from San Francisco. Professor Dana observes of this coal, that it contains considerable pyrites, and burns with much smoke—caking completely. The following is an analysis of specimens he obtained, by Professor Benjamin Silliman, jr.: [2]

Carbon	45.56
Volatile ingredients	52.08
Ash	2.36

LIGNITE.

A very peculiar and interesting brown coal, or lignite, is found near the shores of San Francisco Bay, at Santa Clara, several miles south of San Francisco. It is taken out there in large masses resembling coal, but retaining the grain and structure of wood. The color is a brilliant

[1] When the coal from these localities was used on board of the Active, the trip was made from the Columbia River to San Francisco in fifty-nine hours, and a second trip in sixty-two hours.

[2] Report on the Geology of the United States Exploring Expedition, by J. D. Dana, p. 658.

black, and the masses break with a conchoidal fracture. After long exposure to the air, especially in a dry situation, the mass contracts so much that it becomes traversed by numerous fissures, and may then be broken up by the hand. The powder and streak are dark-brown, in which respect the mass corresponds with lignites or brown coal; but when ignited it burns freely with black smoke and a bituminous odor. It contains a large per centage of bituminous or volatile matter; so much, that it burns with a brilliant flame. It does not leave a large quantity of ash, and these good qualities render it valuble as a fuel.

Not having visited the locality, I cannot describe its geological position and association, nor present any observations upon the extent and thickness of the beds, and their prospective importance and value as a source of fuel. I was, however, informed by the gentlemen who called my attention to the coal that it existed in beds about three feet thick, and that it was overlaid by strata of sandstone.

CHAPTER XX.

METALS, ORES, AND MINERALS.

ORES OF IRON.—MAGNETITE AT THE CAÑADA DE LAS UVAS AND WILLIAMSON'S PASS.—LIMONITE.—COPPER AND ITS ORES.—COPPER PYRITES.—VEIN IN THE GREAT BASIN.—VITREOUS COPPER.—NATIVE COPPER AND RED OXIDE OF COPPER.—SULPHURET OF ANTIMONY.—DESCRIPTION OF THE VEIN AND ITS ASSOCIATION.—METALLURGY OF THE ORES OF ANTIMONY.—FURNACES.—LOCATION OF THE VEIN.—LEAD.—SULPHURET OF MERCURY, CINNABAR.—DESCRIPTION OF THE ORE AND MINE.—FURNACES FOR THE EXTRACTION OF THE METAL.—GOLD.—INDICATIONS OF GOLD ALONG THE ROUTE.—QUARTZ VEINS.—PLACERS NEAR THE SAN FRANCISQUITO RANCHO.—AURIFEROUS VEIN AT ARMAGOSA.—COLORADO RIVER.—GOLD AT PORT ORFORD.—CRYSTALLINE GOLD.—PLATINUM AND IRIDOSMINE.—ANALYSIS.—SILVER.—TELLURET OF SILVER, HESSITE.—NATIVE ARSENIC.—CHROMIC IRON.—EMERALD NICKEL.—ILMENITE.—TOURMALINE.—ANDALUSITE OR MACLE.—FELDSPAR.—BRONZITE OR DIALLAGE.—CHRYSOTILE.—GYPSUM.—CARBONATE OF LIME.—CARBONATE OF MAGNESIA.—SALT.—CARBONATE OF SODA.

The objects of the expedition did not permit of extended observations, at any great distance, on either side of the route explored. Mining localities, and veins of auriferous quartz in the southern mines, were passed by without my having any opportunity to examine them; and it is doubtless the fact, that many other interesting mineral localities were passed, from time to time, in the hurried transits made from one field of operation to another. The following notices of interesting mineral veins, and localities of minerals, are of those that were incidentally met with in the course of the survey, or were afterwards visited or brought to my notice, and they are not to be regarded as an exposition of the mineral resources of California.

IRON ORE—MAGNETITE.

Cañada de las Uvas.—Magnetic iron ore occurs in a vein about three feet thick, in a low ridge of white crystalline limestone, in the valley of the Pass known as the Cañada de las Uvas. This ridge is near the highest point of the Pass, and the debris of the ore rolls down close to the trail. The vein, or bed of ore, is nearly vertical; its trend is nearly east and west, and the outcrop is traceable for about thirty feet. The ore is much mixed with the carbonate of lime, but no other minerals of association were observed. It is compact, but not crystalline. When broken it shows a brilliant fracture, with a granular surface, and does not cleave, with broad, flat faces, as in the massive magnetic ores of New York and New Jersey.

Williamson's Pass.—Large rolled masses of magnetite were picked up in the bed of one of the streams entering the valley of Williamson's Pass, on the east side. The ore is very pure and crystalline, and is associated with hornblende, cinnamon-colored garnets, and chlorite. It probably exists in a considerable vein between the Pass and the Cajon; and judging from the beauty of the minerals of association displayed even in the rolled fragments, the vein may be expected to yield specimens of interest to the mineralogist.

Volcanoville, on the Middle Fork of the American River.—Large masses of magnetic iron-ore occur in a slight ravine, among boulders of quartz and other rocks, near the great vein of auriferous quartz at Volcanoville. Their source is not known, but it is probably in the vicinity. It must form a thick bed, judging from the size and number of the transported masses.

LIMONITE.

Burns' Creek, Mariposa County.—An outcrop of hydrous sesquioxide of iron occurs near the banks of this creek, on the right of the road going south. Its position, and its geological association, has already been noted in Chapter II.

It is associated with a quartz vein, and both together form a bed about twenty-five feet thick, lying conformably with talcose and chloritic slates. The layers of slate adjoining the vein are more or less charged with the oxide, and some thin layers are distinctly intercalated. The ore lies upon the surface in great solid blocks, from two to four feet in diameter. It is compact, of a dark-brown color, and breaks with a smooth, conchoidal fracture. Its powder is a dark rusty-brown, and its hardness about five on the scale of Mohs. It is peculiarly compact and hard, and is unlike any specimen of similar chemical composition that I have seen.

Its position and peculiarities indicate that it has resulted from the decomposition of sulphuret of iron, (iron pyrites,) and that it now forms the "gossan" of a vein of sulphuret below the surface. This is probably the case, but the mass does not present that cavernous, porous, and friable condition in which gossan is usually found. An examination by the blowpipe did not show the presence of any sulphur. It is easily reduced, and when carbonized fuses to a magnetic globule. At some future day this ore may be valuable for making iron, but at present the scarcity of fuel and the cost of labor will not admit of its being profitably worked. It contains about fifty-six per cent. of iron.

COPPER PYRITES.

Great Basin.—Yellow copper pyrites was met with on the slope of the Great Basin, about seven and a half miles east of Johnson's River, in the form of loose fragments, covered with a slight green coating of the carbonate. I followed up the bed of a dry brook, along which the fragments had been transported, until I found the parent vein. This is in a micaceous granite, forming one of a series of small isolated hills or ridges at the upper part of the slope, and not more than three miles from the foot of the main range.

The trend of the vein was ascertained to be nearly north 75° east, (magnetic,) and its inclination to the north; but it is nearly vertical. The outcrop consists of quartzose rocks, containing masses and coatings of carbonate of copper and the fine oxide of iron, which sometimes results from the decomposition of pyrites. These indications of a vein were spread over a width of twenty to thirty feet, and were traced for one quarter of a mile. This is a valuable vein, and I have no doubt will show some splendid ore on being opened. It is possible that it is auriferous; but I had no means of determining this question. Its position is such as to discourage any attempt to work it at present. There is no water within three or four miles of the place. Timber can be had from the mountains, four or five miles distant. The ore could be transported to Los Angeles, by mules or wagons, a distance of nearly eighty miles, by the way of Williamson's Pass.

VITREOUS COPPER.

Williamson's Pass.—A sulphuret of copper occurs about seven miles below the summit-level of Williamson's Pass, on the north of the valley and on the slope of a granite hill, about ninety

feet above the bed of the creek. The vein had been "prospected" by some adventurers, and two or three hundred weight of ore had been taken out and piled up.

It is found in strings and narrow veins, distributed in a hard quartz gangue about fifteen feet thick. The thickest seam of ore, however, does not exceed one or two inches, but where several are closely combined, a thickness of eight inches of workable ore was seen. The best part of the ore that has been excavated will probably yield thirty per cent. of copper. The ore is not the common yellow sulphuret, but resembles vitreous copper and the variegated pyrites.

It has not been analyzed, and it is uncertain to which of the two species it may be referred, but it is probably the former. Its color is lead-gray, and it is not harder than calcite. It contains a large per-centage of iron, and being very much mixed with the hard, quartzose gaugue, and so far from water-power and transportation, the vein does not at present offer much inducement for exploration. Timber can be obtained from the adjoining cañons, at a distance of three or four miles. There is no permanent water-power in the vicinity, and the vein is about 60 miles from Los Angeles.

NATIVE COPPER AND RED OXIDE OF COPPER.

While at Fort Yuma, at the junction of the Gila with the Colorado, several large masses of splendid copper ore, brought from the state of Sonora, Mexico, were exhibited to me by the officers of the post, and Mr. Yeager at the ferry. The vein is reported to be near Altar, and a large pile of the ore is said to be deposited near the emigrant trail. This is probably the case, as many specimens are brought in by travellers who cross the Colorado at the ferry below the fort. This ore is principally the red oxide of copper. It is massive, and sub-crystalline, and contains small masses and points of native copper. Its surfaces are covered with green coats and incrustations of the carbonate. It is a very valuable ore, and the specimens that I saw would yield about 90 per cent of pure copper.

The mine has been worked more or less by Mexicans, and the ore taken to Guaymas. The precise locality of the vein could not be ascertained, but probably it is readily accessible from the Gila, and in the event of the construction of a railroad in that vicinity the value of the mine will be much increased, and it will, doubtless, furnish a considerable amount of freight.[1]

SULPHURET OF ANTIMONY.

A large vein of sulphuret of antimony exists in the granitic rocks at the head of the Tulare Valley, near the pass of San Amédio. It is about eighty miles distant from Los Angeles, by way of the nearest trail, and is most readily reached from the Tejon or Cañada de las Uvas.

The Indians and others had reported the ore to be of silver, speaking of the locality as affording "*mucho plata*," and it was also reported that a party of men had been to the locality and reduced some of it in forges and furnaces of rude construction. While in Depot Camp at the Tejon, I made a special visit to the locality, in order to ascertain the true nature of the ore and its composition.

The general direction of the trail to the mine is from the entrance to the Cañada de las Uvas, westward, along the base of the sandstone hills to the third principal cañada, through which a

[1] Since the above was written, a company has been organized in San Francisco and a mine opened in Sonora, which, from the descriptions, I judge to be upon the same vein from which the specimens procured at the fort were taken. A quantity of the ore has been sent to San Francisco.

stream flows, fringed with cotton-woods. This cañada is ascended for about eight miles, in a direction a few degrees west of south. On approaching the junction between the sandstone and granite, the trail turns to the west and passes over to another cañon, and ascends this to the high granite ridges, where trees and water are abundant. The ruins of a log-house, and the forge that has been used to melt the ore, are romantically situated at the lower end of a long but rugged cañada, between high and steep granite ridges. This cañon and the sides of the mountain are heavily timbered with large fir trees.

The ore for the supply of the furnace appears to have been obtained from the numerous transported fragments, mingled with the granite debris brought down the cañon by floods. The ascent of this cañon was commenced in search of the vein, and I was guided by the numerous boulders of solid ore, which were, in some cases, over one foot in diameter. They were traced up to the foot of a steep and rocky channel, descending the almost precipitous side of the mountain, and it was evident that their source was at a very considerable elevation above. The blocks of ore were occasionally met with along this channel, one of them was twenty-seven inches long and from sixteen to eighteen wide. The vein was at length found, at an elevation of about 6,000 feet above the sea.

This vein is bounded on both sides by granite, and it appears to extend in a nearly north and south direction. The outcrop is so situated on the face of the cliff that it was hardly possible to give it a full examination ; and the greater part of it is so much covered from view by a thick crust of decomposed ore, that the thickness of the vein could not be conveniently measured. I judged, however, that the solid or workable part was from four to ten or twelve feet thick. There certainly is an unusual quantity of ore at this locality, and at some future day it will be worked with profit.

The ore is principally compact and massive, and free from gangue. Several specimens of quartz, traversed by thin blades and prismatic masses of the sulphuret, were picked up; and quartz is one of the principal minerals of association. The decomposed parts of the vein are colored yellow by the abundance of antimony ochre ; and crystals of sulphate of lime are distributed through it. When this vein is worked, there will doubtless be many interesting specimens of antimonial minerals obtained. There were no indications of the presence of silver, nor is it probable that this metal is combined with the ore in any quantity. The report that it is rich in silver probably originated in the fancy and hopes of those who first found the locality.

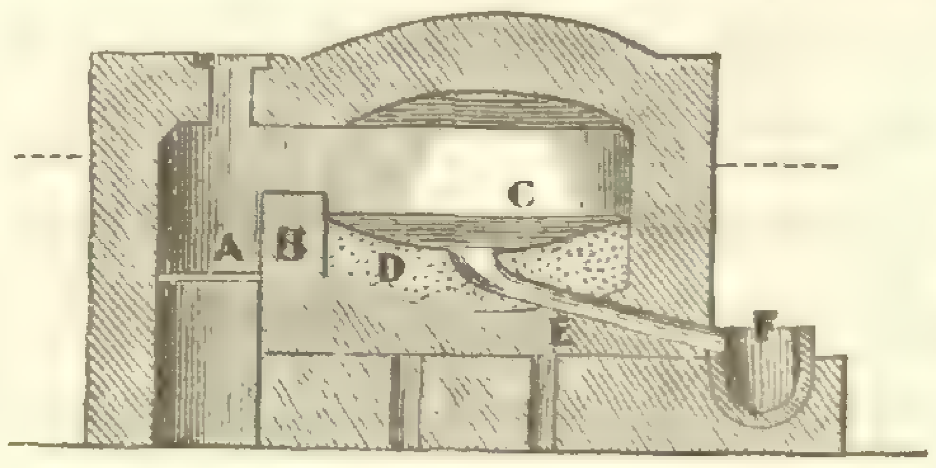
It is merely the sulphuret of antimony, and is commonly known as *Grey Antimony* or *Antimony-Glance*, and is the same as the *Lupus-Metallorum* of the alchemists. It is the most widely diffused ore of this metal, and nearly all the antimony and its compounds, used in the arts and in medicine, are derived from it. The mineral, as generally found, has a bluish-gray color and a metallic lustre, and occurs not only in masses, but in long slender prisms, often divergent, and in lamellar masses, which cleave easily, and expose brilliant surfaces. It is very brittle, and is easily reduced to a fine powder. Chemical analysis shows the presence of from seventy-two to seventy-four parts of metal in one hundred, the remainder being sulphur.

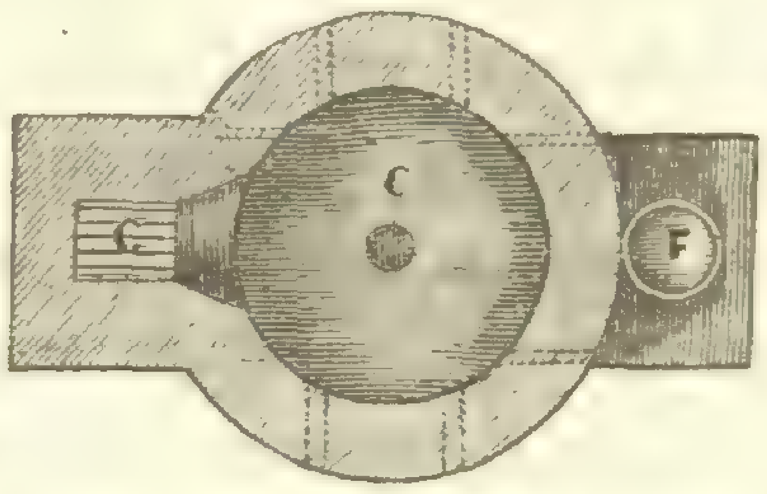
The principal localities of the ore are Felsobanya, Schemnitz and Kremnitz, in Hungary, where it is found in prismatic masses, often several inches in length, traversing the crystals of barytes and other minerals with which it is associated. It is also obtained at Wolfsthal, in Hungary, where it forms a compact vein. In England, it occurs both fibrous and laminated, in Dumfrieshire, and massive in the southwestern part of the county of Cornwall. It is found in France, in South America, and sparingly in the United States, at Carmel, Maine, and,

according to Dr. Jackson, in New Hampshire, at Cornish and Lyme, where it is associated with quartz. But the most important locality known is in the island of Borneo, from which the principal supply of the world is obtained. The mines are upon the west side of the island, and within twenty miles of the sea. They are reported to be the property of Sir James Brooke, and to be very valuable.

Treatment of the ores of antimony for the separation of the metal.—The separation of antimony from the gangue and sulphur requires two distinct operations. The first has for its object the simple separation of the sulphuret, from the minerals with which it is associated, and the second consists in the reduction of the sulphuret, or the separation of the sulphur and the antimony. The first is effected by simple fusion, or a process called liquation, and gives, as a result, the *crude antimony* of commerce; the second yields the *regulus* of *antimony*.

The operation of liquation may be performed in a rude manner by placing the ore in an earthen pot or crucible, the bottom of which is pierced with small holes. This is set upon or into the top of another pot which is imbedded in the earth. The joint being luted with clay, and the upper pot tightly covered, it is heated for several hours, the fuel being piled around the pot containing the ore. The sulphuret of antimony fuses and drains out of the gangue, passing through the holes in the bottom of the pot into the vessel below, where, on cooling, a mass of crude antimony is found. In operating in the large way, it is necessary to observe a greater economy of fuel and to avoid the constant interruption of the operation. One of the most simple of the furnaces contrived for this purpose is described by Dumas as in use in the department of Vendée, France, and consists of a reverberatory furnace of a circular form,





REVERBERATORY FURNACE FOR EXTRACTING CRUDE ANTIMONY.

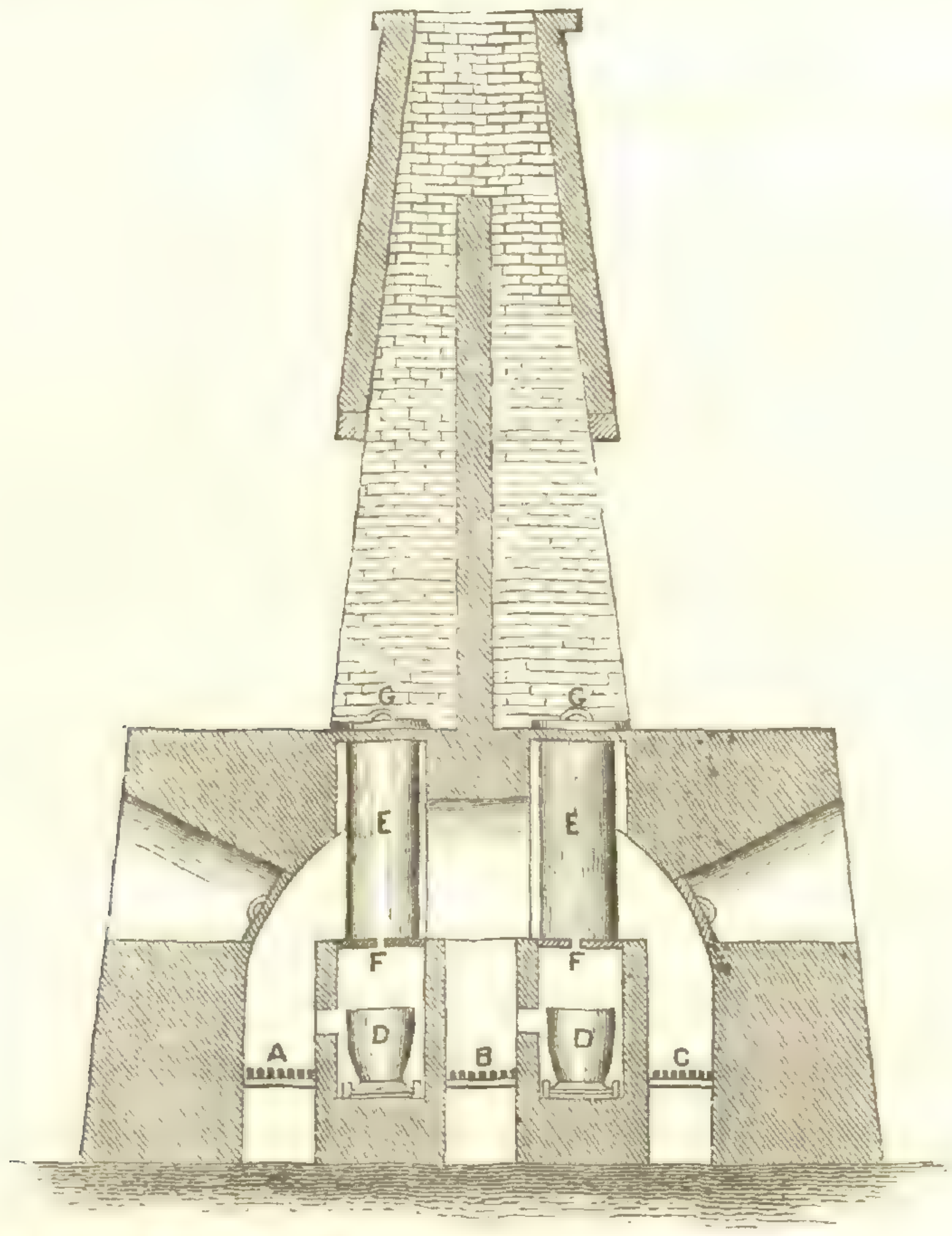
shown in section in the figure. The floor of the surface is concave, and formed of a mixture of clay and charcoal. Upon this the mineral is laid, and, when heated, the fused sulphuret runs out through a pipe into a receptacle on the outside of the furnace.

Another and a more complicated furnace, the invention of M. Panserat, of Alais, has been in use at the mines of Malbosc, in Ardèche. It may be described as a dome-like furnace, in which vertical cylinders (E E in the figure) are so placed that the flames can play around them. These are pierced with a hole at the bottom, and stand upon a hollow support containing earthen pots, D, D, as receptacles. These are placed upon a small car, or frame with wheels, so as to be readily withdrawn or replaced. The mineral is placed in the cylinders in masses of the bigness of an egg; the fire is made upon the grates, A, B, C, and the flames after encircling the cylinders escape into the chimney by openings not shown in the section. The sulphuret being fused drips down into the pots below, which are heated by the fire on each side, and so retain the mineral in its melted state until it is withdrawn and poured off.[1]

Metallic antimony is obtained by first roasting the sulphuret so as to expel as much of the sulphur as possible and form an oxide. This is afterwards reduced by heating in crucibles with

[1] This description of the furnace is condensed from Dumas *Traité de Chimie Appliquée aux Arts*, t. iv, pp. 168, 169.

charcoal and carbonate of soda ; the complete decomposition of the sulphuret being effected by the carbonate of soda.



FURNACE FOR THE EXTRACTION OF CRUDE ANTIMONY.

It was for a long time attempted to prepare metallic antimony by heating the sulphuret with iron in the presence of charcoal and alkalies ; but this proceeding is now generally abandoned ; for the iron combines with the antimony and a poor quality of metal results.

The regulus of antimony of commerce is not pure, but contains sulphur, iron, lead, and arsenic ; the latter being very difficult to separate. The most simple process for the extraction of the arsenic, according to Pelouze and Fremy,[1] is to transform the arsenic and the antimony into arseniate of soda and into antimoniate of soda, neutral and anhydrous. The first of these salts can be removed by means of hot water, in which it is soluble, while the antimoniate of soda is insoluble.

Access to the Vein, and Facilities for Mining.—The position of the vein at so great an elevation renders it somewhat difficult of access ; but it may be approached from the side of the mountain, opposite to that ascended by me, with much greater facility. It would, however, be possible, and perhaps the least expensive course, to construct a slide of timbers, on which the ore could be sent down to the foot of the mountain. It could then be loaded on mules, and taken to San Pedro, the nearest seaport. There is an ample supply of pine timber on the top of the mountain above the vein. It is sufficient for all the purposes of mining, or for reduction of the ore, which might be conducted at the mine with little expense beyond the cost of labor. There is no water power in the immediate vicinity of the vein except during the winter or rainy season. As, however, the mine will be completely dry, pumps will not be required ; and the mine can be worked in such a manner that it will not be necessary to lift the ore by machinery.

The spring in the lower part of the cañon near the old forge appears to be unfailing. There is also a small spring on the side of the mountain near the vein, and it can probably be enlarged, so that sufficient water can be obtained there for miners. There are many little open valleys

[1] Pelouze et Fremy, Chimie, ii, p. 526.

and slopes in the vicinity, which are suitable for cultivation, and there is abundance of grass for animals. Game of all kinds is very abundant; bears, deer, antelope, and mountain sheep were seen in the vicinity.

This vein of antimony ore is of great importance and well worthy of exploration.

LEAD.

The ores of lead do not appear to be abundant in California, and there are no mines of it or veins of sufficient extent to warrant working yet known. Galena occurs as an associate of native gold in quartz at the Marble Springs mine in Tuolumne county. It is mingled with blende, and in some parts of the vein forms large bunches. This association is peculiar, and forms very pleasing specimens for the cabinet. The mine is in the limestone region, and it is probable that other and more important localities will be found along that belt.

Argentiferous galena occurs at the Alisal Rancho in Monterey county, associated with pyrites and arsenical minerals. It is said to occur in considerable quantity, and to have been worked more or less for several years, but with little success.

SULPHURET OF MERCURY—CINNABAR.

This ore of mercury is found at New Almaden, on the eastern slope of the mountains extending between the valley of San José and the Pacific. The works for the extraction of the metal are about twelve miles south of the village of San José, in one of the narrow valleys of the mountains, and the entrance to the mine is about one mile distant, and several hundred feet higher. The sulphuret (cinnabar) is the only ore which occurs at this locality, and is found intercalated with layers of flint and shales in a series of lenticular beds and interlaminations. These rocks appear to be metamorphosed strata, and they crop out on the surface at several places below the mine. They consist of regular beds of argillaceous shales and layers of flint and jaspery rock, which simulate those occurring at San Francisco near the Mission, at Fort Point, and Lime Point. Dykes of serpentine, apparently intrusive, are found in or near the mine, and trappean rocks are also found in the vicinity.

The similarity of the strata and of the serpentine to those found near San Francisco leads me to consider them of the same age; and the probability that the flinty and jaspery rocks are the metamorphosed blue sandstone of San Francisco Bay has already been adverted to.

It is generally supposed that this ore is in a great "*bunch*," or "*pocket*," and without any definite extension in one direction more than another. This, however, is not the case, as it has an evident prolongation; and although probably not a *vein of fissure*, much assistance in working the mine may be derived from a knowledge of its true character and the direction in which it extends.

The excavations of the mine are exceedingly irregular. They extend and ramify in all directions; and the different parts are reached by means of slopes, with rude stairs cut in the rock, or by notched poles. The ore has been excavated wherever it was most abundant; and in some places pillars of it are left standing to support the roof. One mass of solid cinnabar was eight feet thick. The mine is free from water, and no decomposition of the ore has taken place. Sulphurets of iron and copper and arsenical pyrites are found in some parts of the veins, but

they are in small quantity. Veins of crystallized carbonate of lime traverse the cinnabar, and fault the small beds and strings of the ore. Bitumen is occasionally found associated with the calcite.

The mines and works are under the able superintendence of Captain H. W. Halleck, formerly of the United States engineer corps, and he has introduced many improvements. A large tunnel has been cut in on the side of the mountain, and a wide track laid, on which cars run in to the centre of the works and are loaded with the massive ore. On reaching the surface it is assorted, weighed, and packed upon mules, and thus transported down the mountain to the works for the extraction of the metal.

From the descriptions given of the ore and mine of Almaden, in Spain, it would appear that there are many points of similarity in the two localities. The vein at Almaden is described as very thick, and composed of massive cinnabar. It is also reached by a tunnel.[1] The furnaces at New Almaden differ from any in use elsewhere, and are very simple and effective. The large blocks of ore, and rock containing it, are not crushed, but are piled loosely together in a brick chamber, as if they were to be roasted. The flames from an exterior fire are made to pass through this chamber and the ore; and the products of combustion, together with volatilized sulphuret, pass on through a series of chambers until the separation of the sulphur and the mercury is complete, and the metal is condensed. The smoke, sulphurous, and carbonic acids escape through a tall chimney. In this process the sulphur appears to be oxidized by the free oxygen which passes through the fuel. No lime is used, and there is no necessity for crushing the ore; it is an exceedingly simple process, but is adapted to that peculiar ore only.

Some idea of the amount of quicksilver which this mine produces may be obtained from the record of the amount exported from San Francisco—all of it the production of the mine, but exclusive of the large quantity used in the State. This, in 1856, amounted in value to $831,724.[2]

GOLD.

The route followed by the Expedition passed within a few miles of the great auriferous quartz veins of Mariposa county, and, for a part of the time in that vicinity, over earth which would doubtless yield gold if prospected under favorable circumstances—water being very scarce. We were also at one time very near a mining town called Quartzburg, so named from the number of the quartz veins in the vicinity, and the mills erected there for crushing the quartz and extracting the gold.

This region appears to be peculiarly rich in huge quartz veins, or "*dykes*" and "*ledges*," as

[1] I copy the following notice of the Almaden mines from the Journal of the Geological Society of London: "These mining works were known to the Romans. A long, tunnel-like gallery, the Socabon del Castillo, lined throughout with freestone, roomy enough to admit of carts with two horses abreast, and furnished on both sides with granite foot-ways, passes from the flat valley, at the southern side of the ridge, on which Almada is built, into the mine; the whole town is undermined. From this tunnel many other passages are cut into the clay-slate, which is the matrix of the ore, one of which opens into the Boveda de Santa Clara, a dome-shaped hall, fifty-one feet high, and forty-two feet broad. Here formerly stood a horse-winch for the removal of the ore. The workings reach a depth of 1,140 feet. The cinnabar vein, with a strike east and west, and a nearly perpendicular dip of from 60° to 70°, has an almost fabulous bulk. In the first story, of which the mine has nine, the vein is eighteen feet strong; in the lowest it is 60′. The spectacle of this colossal vein of ore at the working places is gorgeous, from the dark-red color of the cinnabar, which appears sometimes earthy, sometimes in dense masses, and sometimes even finely crystallized. Dispersed through it are calcspar druses, and at many places small holes and clefts are filled with pure quicksilver."—(*Jour. Geol Soc. London VII*, 1850-51. *Translated from Leonhard U. Bronn's N. Jahrb. F. Min. W. S. W.*, 1850, 4 *H*, *p.* 497; *and Bergwerk's freund*, 1849, *XIII*, *p.* 72, *et seq.*

[2] Report on Commerce and Navigation for 1856, page 340.

they are very commonly called. We could see over a very considerable extent of the surface of the hills east of us, and here and there, long, white, lines like walls of stone were visible. These were the outcrops of the quartz veins, trending, for the most part, parallel with the bedding of the metamorphic slates which they traverse. An outcrop near our trail formed a conspicuous

OUTCROP OF A GREAT QUARTZ VEIN.

feature in the scenery. The great blocks of snowy whiteness contrasted finely with the dark-colored slates on each side; and, being little acted on by the weather, have accumulated in a long line, like a cyclopean wall, while the surrounding rocky foundations have mouldered away.

This, and similar ledges of dense, vitreous quartz, are not favorably regarded in the gold region, for the very good reason that they seldom contain gold; or if in small quantity, the labor of extraction is too expensive to be undertaken.

Another great vein of quartz, near the road we followed, was rendered very interesting by its association with a very compact but hydrated peroxide of iron. This ore presents some remarkable peculiarities at this locality, and is described in another part of this chapter. It is probable that this ferruginous quartz vein is auriferous, but no gold could be detected by the eye.

From this vein to the Mariposa river, we passed along the border of the gold region; and an occasional quartz vein was seen. A great part of the ground that we passed over was highly colored with oxide of iron, and loose fragments of quartz were numerous on the surface.

On the Fresno and San Joaquin rivers, miners were at work; and a considerable quantity of fine scale gold was being removed from the alluvial drift. Between the San Joaquin River and Posuncula or Kern River, rocks of the auriferous series were seen at several places; especially

along the Four Creeks, Tule River, Moore's and White Creek. Along this part of the route there were many indications of gold; but I could not learn that this section had been prospected with any success. I "panned out" some of the gravel and sand from the beds of several of the creeks, and did not obtain gold; but there was no opportunity for a fair trial, and the result could not be considered as conclusive.

While encamped near Posuncula River, a party of prospectors returned from its headwaters, and reported the existence of gold; since that time, extensive and rich deposits have been opened and worked.

Placers near the San Francisquito Rancho.—The auriferous slates, or talcose and micaceous slates, resembling those of the gold regions of the Sierra and of the Atlantic slope, which occur in the Bernardino Sierra, at the Pass of San Francisquito, have already been described. That region has been known as auriferous for many years, and placer mines were worked there long before the gold on the slope of the Sierra Nevada was discovered.

According to De Mofras, the gold of the San Francisquito Rancho was first explored by M. Charles Baric, a Frenchman. He gives its distance in the mountains as six leagues to the northward of the Mission of San Fernando, and fifteen leagues from Los Angeles. He further states: "This vein has an extent of six leagues, following the direction of the ravine where it is situated. The gold is found near the surface of the soil, and some pieces weigh two to three drachms."[1] This description leads me to regard the deposit as a *placer*, along the tsream, although it is described as a vein (*filon.*) Since the locality was examined, accounts have been received from Los Angeles, stating that a placer had been discovered about eighteen miles from that city. The gold is described as being in the usual form of fine scales and grains; but the richness of the placer does not yet compare favorably with those at the base of the Sierra Nevada.

Armagosa Mines, Great Basin.—A vein of auriferous quartz occurs in the Great Basin, not far from the Mormon trail to the Great Salt Lake, and about one hundred and seventy miles from Los Angeles. This locality has been prospected by parties from San Francisco, and several companies have been organized to work it, but have not been successful, and the mine is now abandoned. I have not been able to obtain any reliable information of the quantity, or mineralogical and geological association of the gold; except, that it occurs in masses of considerable weight, ramifying through the gangue.

Several small specimens which I have obtained show that carbonate of lime is one of the principal minerals of the gangue, and filaments of gold are found penetrating the mineral in all directions. A small rombohedron of calc spar, obtained by cleavage, contains a short string of gold about the size of a knitting-needle, which protrudes from the opposite faces and appears to have been entirely embedded in the calcite.

The locality is far in the interior, and in the midst of a most forbidding and desolate country. It would require a very rich vein to encourage extensive operations; and they must always be attended with great expense, in consequence of the distance from provisions, or land fitted for agriculture.

The fact, however, that gold exists in considerable quantity at this point, so far east of the Sierra Nevada, is a significant one, and of great importance.

The wide expanse of the Great Basin is made up of granitic ridges and their slopes, forming a broad area of bare granitic rocks and their debris. The existence of gold *in place*, in one of

[1] De Mofras' Exploration of Oregon and California.

these ridges, indicates its existence in others; and large quantities of the metal have probably been ground out by denudation and mingled with the debris; thus forming placers which may possibly equal in richness those of the Sierra Nevada. The scarcity of water in those desert wastes is a great bar to exploration, and to the practical testing of the richness of the drift. If, however, gold should be found to exist in considerable quantities in the lower strata of drift, it is probable that water from distant streams could be brought to bear upon it.

Colorado River.—Gold is reported to exist in the mountain ranges north of the Desert, and bordering the Colorado. When at Fort Yuma, a party of prospectors returned from a short trip among these ranges, and also from the mountains on the east side of the stream. They report gold as existing in the ravines and cañons; but it is far from water, and they were obliged to transport the earth that they tested several miles before washing it out. I visited the extreme point of the range north of Pilot Knob, and found numerous quartz veins traversing the granite and metamorphic rocks; but there was nothing in their appearance that indicated the presence of gold. In some of the arroyos, leading from the mountain, a large amount of brilliant, black sand was found, mingled with small, but perfectly formed, garnets. It is mingled with the debris of granite; and no evidences of the presence of the magnesian gold-bearing rocks were seen.

Coast Mountains.—Gold is reported to have been found at various places in the Coast Mountains; in the Santa Cruz range, nearly west of New Almaden; and in the counties of Monterey, Santa Clara, San Luis Obispo, and San Diego.

Port Orford.—The gold of Port Orford, on the coast, is exceedingly interesting for the quantity of Platinum, Iridium, and Osmium with which it is associated. It is in very fine, round scales, and is found upon the beach mixed with great quantities of heavy, black sand, from which it is separated with great difficulty. The quantity of platinum, or mixed metals, is variable, ranging from five to twenty per cent., or more. As these metals cannot be separated from the gold by washing, the value of the product is much lessened, and it is often difficult to make a sale of the mixed metals in San Francisco. An analysis of the metals is given beyond.

Crystalline Gold.—Among the heaps of placer gold in grains, scales, and lumps which accumulate in the banking and assay offices of the chief mining towns, and in San Francisco, bruised and water-worn crystals are sometimes found.

In comparison with the great bulk of the gold, their number or weight is very slight. Even the bruised specimens are comparatively rare. This arises, in part, from the habit among the miners of retaining curiously-formed specimens for their own use and gratification; but it is certain that the great bulk of the gold product is so much worn by attrition that, if crystals formerly existed, their angles are now lost. In some sections of the gold region crystalline masses of great beauty are found even in the drift.

At Forest Hill, Placer county, I obtained several well-formed octahedrons, about three-eighths of an inch across the base. Most of these crystals are but little water-worn, but are generally distorted or flattened parallel to a face of the octahedron, so that they become mere triangular plates. Some of the octahedrons have the hollow or depressed faces. An imperfect octahedral crystal, of great size, was once taken from the drift of this claim. The planes were only partially developed for a short distance above and below the basal ridges, so that a hollow or cavernous crystal was produced. A succession of planes had commenced to form one inside of the other, and were separated by about the thickness of a card, while the sheets of gold forming the planes were, in some instances, not thicker than paper. The crystal was slightly elongated

in the direction of two opposite basal edges, and was thus an imperfect rectangular octahedron. Its greatest length of base is one inch, and in the other direction it is seven-eighths of an inch. When found, all the spaces between the interior plates of gold were charged with a hard crust of peroxide of iron.

The most beautiful specimens of crystalline gold are those in which the crystals are combined with an arborescent or dendritic growth of the metal like the leaves of ferns or the foliage of the arbor vitæ. Specimens of this character are not found among the rudely transported drift, but can be obtained only from their original bed in the solid rocks. Some of the most remarkable and beautiful specimens ever seen were taken out of the cavities of a quartz vein at Irish Creek, about three miles from Coloma. They presented various and complicated combinations, being arborescent, in broad, paper-like sheets, studded with brilliant crystals, and in solid octahedrons. These were combined together in the most interesting manner, giving an effect far beyond the reach of art.

A very fine specimen of this character in my collection has the form of a leaf; one side is arborescent and very brilliant, and the other is studded with about twenty-five perfect octahedral crystals. They are geometrically arranged, all their similar edges being parallel. This is believed to be the most beautiful and curious specimen known. Its weight is seventeen pennyweights and ten grains. Length, two and one-quarter inches; width, one and a half.

One of the largest specimens of this arborescent and foliated gold from Irish Creek was about twelve inches long and about four broad. A part of the specimen was a plate three or four inches long, covered with triangular marks; the remainder was arborescent, and the whole appeared to have grown from one end. Another specimen, slightly different in its character, and probably from another locality in the vicinity, was ten inches long, three broad, and about half an inch thick. It weighed thirty-one ounces, and was free from quartz; forming a most beautiful mass of a rich yellow color, and a delicately-marked surface, consisting of a net-work of fibres. It appeared like a bundle of broken fern-leaves closely matted together.

With one exception, all of the crystals which have come under my observation are *octahedrons;* not a single cube has been seen. The exception is a single crystal, a pentagonal dodecahedron, upon one of the broad plates of gold.

PLATINUM AND IRIDOSMINE—PLATINIRIDIUM.

Grains and scales of Platinum, Iridosmine, and the associate metals, occur with the gold in almost all parts of the great gold-field, but are most abundant in the northern mines. These metals constitute a very large part of the product of the washing of the black sands of the beach at Port Orford and the coast in its vicinity. They cannot be separated from the thin scales of gold by washing, and amalgamation with mercury is resorted to by the miners to obtain the latter. After the removal of the gold the residue is found to consist, in part, of round, flattened scales of Platinum or Platiniridium, which are mostly lifted by a magnet. Two or three ounces of this residue were obtained in San Francisco from a miner who had returned from the locality, and a portion of the sample was submitted to Dr. F. A. Genth, of Philadelphia, for chemical investigation. An analysis was made in his laboratory by Mr. Charles A. Kurlbaum, jr., with the following results:

Insoluble in aqua regia, (Osmiridium)	48.77
Platinum	43.54
Iridium	0.60
Rhodium	0.28

Palladium	0.49
Gold	1.32
Silver	0.13
Copper	0.32
Lead	0.03
Iron	4.52
	100.00

The Platinum separated by the analysis is found to be almost pure, containing but little Iridium.

SILVER.

Silver is not yet obtained by mining in California, except in combination with the gold. Its ores have been found, however, at several points, and it is probable that when the attention of the mining population is to some extent diverted from the development of the riches of the placers and auriferous veins, veins of silver will be discovered. The ores, however, are not generally known, and may frequently be passed over in ignorance.

During my residence in San Francisco the attention of the public was frequently excited by glowing reports of the discovery of immense deposits of silver ore in Monterey county. Some specimens of this ore were sent to San Francisco, and being handed to me for examination, proved to be an excellent article of chrome-iron ore. The specimens had the green crusts and coatings which are so common in the fissures of the massive chrome ore of Wood's Pit, Maryland, and which are the oxide and carbonate of nickel—Emerald nickel of the mineralogists. Numerous reports were also in circulation concerning a great vein of silver ore in the mountains north and west of the Mission of San Fernando. This ore was no other than the *sulphuret of antimony* in the San Amédio Mountain, already described.

At the Alisal Rancho, in Monterey county, veins of silver, bearing galena and sulphuret of iron, are found traversing a white granitic rock, composed, near the vein, of quartz and feldspar in nearly equal parts. These veins are about twenty-five miles distant from the Mission of San Carlos, and are on the east side of the Salinas Valley, in the foot-hills. Three veins are reported to exist there, one having been recently discovered. The locality is said to have been known for a long time, and to have been resorted to by Indians before the settlement of the country. It is also stated that the vein was worked in 1831 by a Mexican miner. It was again worked in 1852 by Germans, but without success. I have not visited this locality, but have recently received several specimens from three veins, including the one but recently discovered, (in 1855.) One of the specimens from the old vein has a rusty-brown appearance like the surface specimens of a ferruginous vein of lead ores ; the cleavage surface of galena was distinct, and a small cavity was lined with small, translucent crystals, which appeared to be *cerusite*, (carbonate of lead.) This specimen has the appearance of an argentiferous galena, and doubtless will yield a fair amount of silver on cupellation.

Another specimen consisted of compact quartz, with traces of sulphuret of iron and copper. It is stained with the blue and green carbonates of copper—azurite and malachite. A third specimen contained, in addition to sulphuret of iron, a dark, brittle mineral, in small quantity, which proved to be metallic arsenic.

According to De Mofras, silver ores occur about two leagues northwest of Cohuenga Rancho, and were not worked for want of mercury and knowledge of processes. He further observes that the Indians often bring in from the mountains, grains of copper, fragments of opal, and

pieces of galena. Mines of gold and silver are also said to have been found about fourteen leagues from San Diego. They were once worked by a man from Guanajuato.[1]

Silver, in combination with tellurium, has been found at two or more places in the mining region, in the auriferous drift. It is reported, also, that a fragment of native silver was obtained from the auriferous gravel near Mokelumne Hill.

We may look with considerable confidence for argentiferous minerals in the region of the great belt of the metamorphic limestone, which traverses several counties, if not the entire length of the State.

TELLURET OF SILVER—HESSITE?

A mineral, which gives all the reactions for tellurium and silver, was obtained near Georgetown, El Dorado county. It resembles a fragment of tarnished lead or silver glance, but is chiefly composed of silver and tellurium, and is probably the species *Hessite*. The mass is about one inch in length and breadth, and is entirely free from gangue, but incloses native gold, which appears at several points on its surface. An aggregation of cubical crystals, resembling galena, is implanted on one side, and the other is deeply indented with angular cavities, probably the print of quartz crystals.

The massive portions of the specimens are sectile and malleable, and do not show any traces of crystalization; they may be cut with a knife, like lead, and give a brilliant metallic surface. The hardness is about equal to 2 on the scale of Mohs.

In the open tube, before the blowpipe flame, the mineral fuses quietly, coloring the glass a bright yellow under the assay; a white, or gray, sublimate is deposited at a short distance, or immediately over it, which, on being heated, fuses into transparent drops resembling oil. On charcoal it fuses readily to a leaden-colored globule, which, on cooling, becomes covered with little points or dendrites. This globule flattens under the hammer, but breaks on the edges. With the addition of a little carbonate of soda, a globule of silver is readily obtained. A fragment, heated to redness in a closed tube or matrass, with carbonate of soda and charcoal dust, gives, on the addition of a few drops of boiling water, the beautiful violet-red or purple solution described by Berzelius as characteristic of tellurium. This solution loses its color after standing for some time, and a dark-colored powder is deposited. The mineral dissolves in hot nitric acid, with the separation of tellurous acid in crystals. The specific gravity is found to be 8.33.

The color of this mineral is darker than the Hessite of Savodinsky, Siberia, and it is not quite so hard. Hessite, according to the analysis by G. Rose, has the following composition:[2]

Tellurium	36.96
Silver	62.42
Iron	.24

I am indebted to P. C. Currier, esq., of Georgetown, for the specimen which has been described. It was obtained in that vicinity, and probably taken from the auriferous drift with gold, but it cannot have been transported far from its original source.

A specimen seen in the possession of a broker in San Francisco, in 1854, greatly resembled the massive part of the specimen just described. The small fragment of it which was then obtained also gives the reactions for tellurium and silver. Its precise locality is not known. It is probable that tellurium, combined with silver, lead, or bismuth, will be found in the

[1] De Mofras' Exploration of Oregon and California.

[2] Quoted in Dana's Mineralogy, vol. ii., page 44.

auriferous quartz of Grass Valley, and other localities. A few specimens in my collection contain small, brilliant grains resembling tetradymite, but their exact character is not yet determined.[1]

ARSENIC.

This metal occurs, in connexion with argentiferous galena and sulphurets of iron and copper, at the Alisal Rancho, in Monterey county, twenty-five miles from the Mission of San Carlos. This mineral, on being heated, passes off in vapor, and burns quickly, forming a white cloud of arsenious acid—the "arsenic" of the shops. It will thus be seen that the roasting or smelting of this ore would be highly dangerous to the workmen. Arsenic is a common associate of silver ores.

CHROMIC IRON.

Extensive beds of massive chromic iron are said to exist in the mountains of Monterey county. Masses of the ore which were submitted to me for examination proved to be fully equal to the best ore of the northern counties of Maryland and of Lancaster county, Pennsylvania. The resemblance of the specimens to the massive ore from "Wood's Pit" is so close that specimens could not be distinguished if mingled. Crusts of emerald nickel, of the same beautiful dark-green color as that found on the Maryland ores, covered portions of the specimens.

This mineral is used for the manufacture of bichromate of potash, and has been mined to a considerable in Maryland, and exported. A supply is now more cheaply obtained from Asia Minor.

EMERALD NICKEL.

The green coats and compact crusts which are found in the seams of the chromic iron of Monterey county correspond with the *emerald nickel* associated with the chrome ores of "Wood's Pit," near the line between Maryland and Pennsylvania. This mineral was first brought to notice by Professor B. Silliman, jr., and is a hydrated carbonate of nickel, with the following composition in 100 parts:[2]

Oxyde of nickel	58.811
Carbonic acid	11.691
Water	29.498

This mineral does not occur in quantities sufficient to warrant working the locality for nickel. It is, apparently, a product of decomposition of the gangue of the chrome ore, for at Wood's Pit a considerable amount of nickel is found in the associate minerals.

ILMENITE.

A beautiful compound crystal of this mineral was obtained from Georgetown, El Dorado county, it having been taken from the gold washings of that vicinity. The crystalline planes are very perfect and brilliant, but there are few modifications. The only planes noted are those of the rhombohedron and a broad triangular plane upon the axis, resulting from the truncation of the solid vertical angle.

[1] A notice of the occurrence of telluret of silver in California was communicated to the Academy of Natural Sciences of California, and is published in the American Journal of Science, vol. xxiii, page 270.

[2] B. Silliman, jr., American Journal of Science, second series, vi, 248. Also in Dana's System of Mineralogy.

Ilmenite is a compound of titanic acid and sesquioxide of iron, in varying proportions; the analyses of specimens from various American and European localities showing the presence of from 8 to 53 per cent. of the former, and 46 to 91 of the latter. The mineral has not yet been made use of in the arts. It occurs in great beds in Canada, at St. Paul's Bay, and in crystals, similar to the Georgetown specimen, in the northern part of Sussex county, New Jersey, and in the adjoining town of Amity, Orange county, New York. Its occurrence in grains in the gold sand of California has also been noted by Professor Dana.

TOURMALINE.

Black tourmalines, or crystals of schorl, of immense size are found in the feldspathic veins on the north side of the Valley of San Felipe, San Diego county. Nearly all the crystals are imperfectly formed; and the locality is chiefly interesting for their great size and peculiarities of aggregation, which present some curious phenomena of crystallization. These phenomena will be understood by inspection of the figure, which represents a great number of small, slender prisms of schorl grouped around a central nucleus of two or more larger ones. The outline of the whole group is triangular, and the mass may be considered as forming one crystal. All the interstices between the prisms are filled by *translucent quartz,* and this mineral does not extend beyond the boundary of the group. The whole is imbedded in feldspar. We may consider this to be the frame-work of a large crystal, which was not completed for want of a sufficient amount of bases to combine with the silica, and it is an instructive example of the incorporation of extraneous matter within crystals. This is known to be the source of many conflicting results of chemical analysis, and it is doubtless more common than is generally supposed.

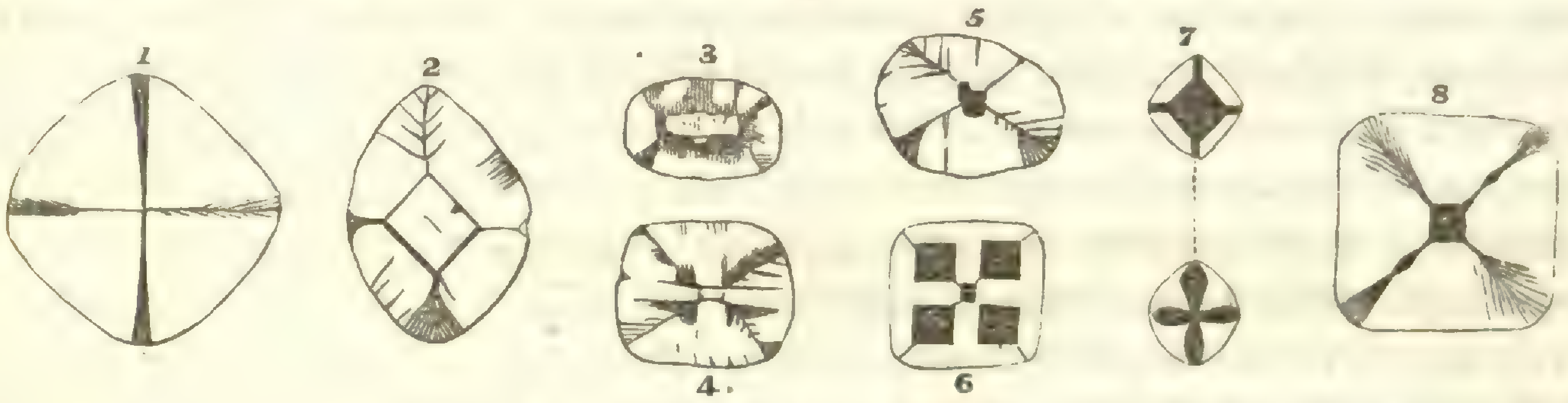
CRYSTAL OF TOURMALINE.

ANDALUSITE.

Remarkably fine specimens of this interesting mineral were obtained in the sands of the Chowchillas River, at the point where it is crossed by the road, and in the upper stratum of the sedimentary deposits which rise in hills on each side of the stream. This stratum is a coarse conglomerate, and is charged with water-worn crystals of the mineral of various sizes. The crystals are also found imbedded in rounded masses of slate—the debris of outcrops higher up on the flanks of the Sierra. Some of the specimens found in the river did not appear to have been derived from the degradation of the conglomerate, and very probably have been transported directly from the original source. The crystals found in the bed of the stream were unusually large, being from one-quarter to over an inch in diameter, and one to two inches long. All the edges and angles were rounded off and worn away in consequence of the constant attrition to which they had been subjected. Some of these crystals present a delicate pink, or rose color, shading into purple, and are translucent.

This mineral occurs in granitic or metamorphic rocks, and is generally disseminated in long prisms in fine-grained mica slate. A mass of slate of this character, filled with Andalusite, was found on the bank of the river. Its color is dark; and it is very fine-grained, consisting chiefly of finely comminuted mica, mingled with clay. It is very compact, and has a silky or satin-like lustre. The crystals are much lighter in color, and, being harder than the slate,

they stand out above its surface, and are thus distinctly presented to view, forming beautiful cabinet specimens. The crystals are mostly exposed on the ends, and they appear rectangular. The specimens obtained at the Chowchillas River, and in the conglomerate, are all of the variety of andalusite called *chiastolite*, or *macle*, formerly considered a distinct species. This variety presents characters which give it a peculiar interest. When the prisms are broken, or ground down at right angles to the main axis, remarkable geometrical figures are exposed. These consist of black lines, or masses, regularly and symetrically disposed around the centre of the crystal, and generally occupying the diagonals of the prism. Various designs are thus produced, and they generally take the form of a cross. These peculiarities will be better understood from the following figures, taken from specimens obtained at the locality.



CRYSTALS OF ANDALUSITE OR MACLE.

These peculiar geometrical figures, so often forming a perfect cross, rendered this mineral in ancient times an object of search for ornamental purposes and for devotional uses. Opposite ends of the same crystal often do not show the same arrangement of the black portions, as shown in figure 7. The central black prism, or nucleus, is often pyramidal in form; and at one end may be nearly as broad as the whole crystal, but at the other appears as a mere point in the centre. This is well shown in one of the specimens taken from the bed of the river, which has been cut and polished by the lapidary in four places. Although the outer surface of the crystal is dark-yellowish drab in color, the interior is quite light, and has a delicate shade of yellow and gray. A brilliant internal reflection from a multitude of points in the mass of the mineral is also seen, and when it is held in certain positions it much resembles some specimens of feldspar. In this light-colored ground the dark, black lines of a cross, or central rectangle, show with distinctness, forming specimens of great beauty. At one end of the crystal this rectangle is quite small, and forms almost a mere point in the centre of the crystal; but each succeeding section, towards the other end, reveals its enlargement, until it finally includes the great body of the prism within its sides.

We must look for an explanation of the formation of these peculiar characters to the arrangement of impurities in the body of the crystal by the forces of crystallization. This explanation was advanced by Beudant,[1] and is supported by the specimens under consideration. Similar phenomena are exhibited in crystals of different salts formed in a fluid containing light impurities. These become inclosed in the mass of the crystal without materially modifying its form, and are found distributed in symetrical figures, their form and direction depending on the system of crystallization. The impurities in the crystals of andalusite consist of portions of the surrounding mica-schist, and a specimen is figured by Dufrénoy, showing the passage of the central black prism into the surrounding rock. This portion has the schistose structure of the rock, and gradually tapers to a point, while the white portions of the crystal increase in thickness as

[1] Traité de Mineralogie, Beudant.

the prism becomes developed. According to M. Durocher,[1] in a memoir upon metamorphism, the four bands of the black material, placed in the diagonals of the prisms, are formed of the same substance as the argillaceous schist which penetrates the interior of the crystal. This material preserves its schistose structure, and the films are disposed in the same plane as in the adjacent rock. The crystals would thus appear to result from the metamorphism of the elements of the schist, they being gradually replaced by a more compact and vitreous substance. Dufrénoy considers that the crystals of macle are the result of igneous action upon sedimentary beds, and states that the most perfectly formed crystals are found near the intruded igneous rocks, while at a distance from them the crystallization becomes indistinct and the prisms appear to pass gradually into the mass of the surrounding rock. He also states that fossils have been found in the midst of schists containing well developed macles. These fossils show the sedimentary origin of the beds, and the macles indicate subsequent metamorphism.

According to Dufrénoy, the two materials which compose the macles are essentially different; the white portions being hard enough to scratch glass, and infusible before the blow-pipe; the black material is easily scratched by a steel point, and is fusible to a black glass.

The specimens which I have obtained, with one or two exceptions, have not the usual hardness; they appear to be changed by long exposure. Nearly all of them are easily scratched by a knife, being nearly or quite as soft as calc-spar; crystals which were found in the stream, and are translucent, are equally soft; but one of a flesh-red or rose color from the conglomerate scratches glass.

Crystals of macle have the specific gravity 2.94 to 3. The chemical composition is identical with andalusite. M. Bunsen has analyzed the white portions of a specimen from Lancaster, Mass., with the following result:

Silica	39.00
Alumina	58.56
Oxide of manganese	0.53
Lime	0.21
	98.30

The specimens from the Chowchillas are unusually large, and present a great variety of interesting figures, and these being formed by dark lines on a nearly white or drab-colored ground are more striking and interesting than those from the well-known locality of Lancaster, Massachusetts. It would be interesting to the mineralogist to visit the original source of the specimens; they must be very abundant, as they now form a not inconsiderable part of the conglomerate which covers the hills. Some interesting developments regarding metamorphism also undoubtedly await the explorer.

According to M. Dufrénoy[2] this curious mineral was observed for the first time by Count Bournon in the mountains of Forez, France. It was afterwards found at Andalusia, in Spain, whence its name, and it has since been obtained at numerous localities in Europe, but always in analogous positions. Fine crystallizations occur in the valley of Lisenz, near Inspruck, in the Tyrol, and at Westford, Massachusetts. It is found in fine specimens at Lancaster and Sterling, Mass.; at Bellows Falls, Vt.; Charlestown, N. H.; Litchfield and Washington, Conn.; and in Maine.

[1] Compte-Rendus de l'Académié des Sciences, xxii, 923, June, 1846.

[2] Traité de Mineralogie, iii, p. 229, Paris, 1847.

FELDSPAR.

Crystals of feldspar occur in San Diego county, in the granite veins along the road between Santa Isabel and San Pasqual, and are associated with tourmalines and garnets. Large and tolerably perfect crystals can be obtained from some of the coarse feldspathic veins. It is probable that they will also be found in the similar coarse veins traversing the metamorphic rocks on the eastern or Gulf side of the chain.

BRONZITE.

The crystals occurring abundantly in the serpentinoid rocks of Fort Point; at the Orphan Asylum, and on the summit of Mount Diablo, are referred to the species bronzite or diallage. It is most distinctly developed at the locality on Mount Diablo, where it forms great rocky masses of confused crystals. In the serpentine near San Francisco, the crystals are isolated in the mass of the rock, and their broad and tabular cleavage faces are exposed when the rock is broken. On exhibiting the specimen from Mount Diablo to Professor Charles U. Shepard, he assured me that it bore the closest resemblance to the bronzite of Bacher Mount, Styria, occurring with serpentine.

Diallage and bronzite are varieties of pyroxene or angite, and are associated with serpentine in New England and Europe. An analysis of a Greenland specimen of bronzite by Kobell yielded:[1]

Silica	58.00
Magnesia	29.66
Protoxide of iron	10.14
Manganese	1.00
Alumina	1.33

An analysis of the California mineral is very desirable.

CHRYSOTILE.

Chrysotile occurs in the serpentine near San Francisco and at New Almaden, forming thin seams resembling amianthus or asbestos. It is seen standing out slightly above the surface of some weather-worn masses, covering them with lines like the reticulations of a net. The seams, so far as observed, are very thin, and do not furnish good cabinet specimens. The mineral is believed to have the composition of serpentine, and is a fibrous variety. It may, however, prove to be fibrous augite or amianthus. An analysis of a specimen of chrysotile from New Haven, Conn., by Professor George J. Brush, yielded:[2]

Silica	44.05
Magnesia	39.24
Protoxide of iron	2.53
Water	13 49

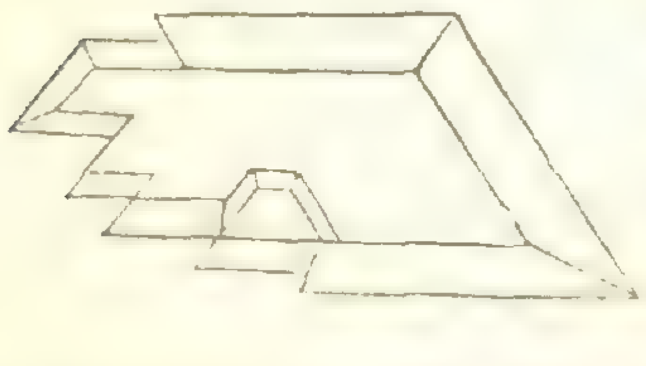
GYPSUM.

Thin transparent plates of selenite are common in the soft, unconsolidated, sedimentary formations in various parts of the State. In some localities it occurs abundantly, and the seams are many inches thick. These seams or layers are generally conformable with the stratification; and some observations upon their origin are already presented in Chapter XIII. This mineral

[1] Journal für pratische Chemie, Ch. xxxvi, 303. Cited in Dana's Mineralogy, 4th ed., p. 162.

[2] Dana's Mineralogy, 4th ed., II, p. 283.

was observed at Benicia (Navy Point) and Ocoya creek. At the antimony vein, near the Pass of San Amédio, it occurs abundantly in crystals, similar in their size and modifications to that represented in the figure. They are found in the decomposed portions of the vein, and good cabinet specimens can be obtained. The mineral was also observed in the Great Basin; near the entrance to the New Pass, and at Carrizo Creek near the Desert. It was not found at either of these places in quantities sufficient for the purposes of the arts or agriculture.



CALCITE—CARBONATE OF LIME.

Several small masses of transparent calcite, equal to the variety called *Iceland spar*, were picked up on the surface of the Colorado Desert, north of the Emigrant Road, from the mouth of the Gila to Carrizo Creek. They are probably washed out of the soft Tertiary strata, in which so many concretions or clay-stones occur. One of the specimens is a perfect crystal, an unmodified rhombohedron—angle 105°. It is about three-quarters of an inch in diameter, and its surface is slightly dimmed or ground by the action of the driving sand.

In the pass through the Peninsula Mountains, called *Jacum*, several miles south of Warner's Pass, thin seams of crystallized carbonate of lime are abundant. The crystals are acute rhombohedrons, about half an inch long, and are thickly implanted upon a thin crust of the same mineral, so that they form interesting cabinet specimens. Small crystals of similar form were noticed in veins and cavities of the white limestone in the Tejon Pass.

At the quicksilver mine, New Almaden, this mineral occurs in obtuse rhombohedrons, lining the cavities in the veins. Veins of calcite are very abundant in this mine, and they traverse the ore in all directions, cutting directly across the small veins and strings of the cinnabar, so that their continuity is completely broken. Small globules of bitumen are sometimes found implanted among the crystals.

MAGNESITE—CARBONATE OF MAGNESIA.

Immense beds of nearly pure carbonate of magnesia were found in the foot-hills of the Sierra Nevada, between the Four Creeks and Moore's Creek. These beds are from one to six feet in thickness, and are interstratified with talcose and chloritic slates and serpentine. The mineral is snowy white, and being on the side of a high ridge, the outcrops are visible from the plain for a distance of several miles.

The rock is compact and homogeneous, and does not show any traces of crystalization, but breaks with a smooth, conchoidal surface, somewhat resembling broken porcelain, but it is not so translucent. Its hardness is not less than 5.2 of the scale of Mohs. It is so hard and dense that it cannot be cut with a knife, but may be ground perfectly smooth, and polished. No other minerals or impurities were observed with these beds; they appear to be nearly pure. An examination showed the presence of a little silica and oxide of iron, probably a carbonate, but of the latter there is not enough to affect the color of the mass, or stain it by decomposition. It contains about forty-seven per cent. of magnesia and fifty-two of carbonic acid. The following analysis, by Professor T. S. Hunt, is of the magnesite of Sutton, Canada East, where it occurs in large quantities:[1]

Carbonate of magnesia	83.35
Carbonate of iron	9.02
Silica, (mixed)	8.03

[1] Report of the progress of the Geological Survey of the Canadas, by Sir W. E. Logan, 1848.

This Canadian magnesite is not so pure as that of California, and it grows yellow by exposure to the weather.

Another specimen in my collection is entirely different in its character, being crystalline and granular, but occurs in masses like limestone. It was presented to me by Dr. Trask, and is from the mining region. It is covered with beautifully green crusts or films, which somewhat resemble thin scales of silicate or carbonate of copper. This rock was supposed to consist of quartz and limestone, but had not been examined, when Mr. Hunt, who saw the specimen, immediately recognized it as nearly identical with the magnesite of Canada, and, on examination, finds that the green films consist of oxides of nickel and chromium. There is an almost unlimited supply of this mineral at the locality near the Four Creeks. It can be used with great advantage in many processes in the arts, and is valuable for the preparation of the various salts of magnesia.

SALT.

The principal locality of common salt, near the line of the survey, is in the hills bordering the Great Basin, on the eastern side of the elevated plain or Valley of Taheechaypah, and near the Tejon Pass. It is said to occur in a thick bed, from which it is excavated by the Indians, several mule loads having been taken to the Tejon for the use of the settlement commenced by Lieutenant Beale. This salt is said to be granular, very clean, and of excellent quality. Not having seen the locality, it is impossible to describe the association of the salt, or to state whether it actually occurs interstratified with clay and sand, in the side of a hill, as is represented. It is possible that it was formed at the bottom of a small lake which has dried up, or which may become dry during the summer.

A thick crust of salt is formed in this manner by the annual evaporation of the water of a shallow pond, called Casteca Lake, near the summit of the Cañada de las Uvas. In the dry season the water all evaporates, and leaves a thick crust of white salt, which the wind acts on and blows about like snow.

A salt lake, or dry lake-bed of salt, is also reported to exist in the lowest part of the northern portion of the Colorado Desert. While we were traversing this Desert, an Indian accompanied us for a short distance from the Cohuilla villages, and then struck off towards the north for salt. Salty incrustations were found around most of the springs of the Desert, and along the streams running into it. The incrustation of Salt Creek, crossed November 20, consists of chloride of sodium and sulphate of magnesia ; and the crust found on the soil at the Cohuilla villages, November 18, is chiefly composed of salt, with sulphate of soda and sulphate of magnesia. The Dry Lake, at the extreme end of the Mojave River, in the Great Basin, has a thick incrustation, formed partly of salt and partly of carbonate of soda and sulphate of magnesia.

Salt also occurs in the soil along the Mojave, near the foot of the slope from the Cajon Pass, and is associated with carbonate of soda, sulphate of soda, and sulphate of magnesia. A mass of rock, at some distance from the river, which appeared moist, was broken into by Lieutenant Williamson, and a hard nucleus reached, which was afterwards found to attract moisture, and could not be kept dry when wrapped in paper. On examination it proves to contain chloride of calcium, in addition to chloride of sodium, nitrate of soda, and sulphate of magnesia.

The coast and climate of California are particularly favorable to the manufacture of salt from sea water. At Monterey, Santa Barbara, and other places, there are extensive but shallow lagoons, separated from the ocean by a narrow, canal-like channel. Such places, on being filled from the sea at high water, may be shut off, and the water then be allowed to evaporate by

the influence of the sun and air alone. It is reported that great deposits of salt, formed in this way by the action of the sea, have been found on islands in the Gulf of California, and are now being worked. Even Vizcaino, in his narrative as long since as 1602, noticed the numerous deposits of salt in Lower California.

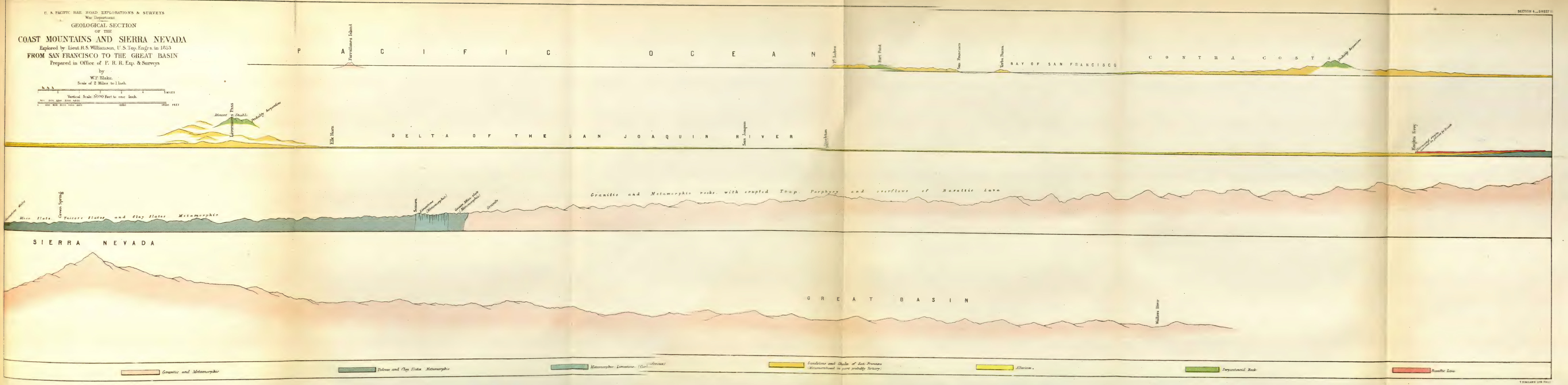
CARBONATE OF SODA.

Carbonate of soda occurs at many places, associated with salt and sulphate of magnesia, but has not been observed in crystals, or so isolated from other salts as to be specifically recognized.

It occurs, with other salts, at the borders of Kern Lake, Tulare Valley ; in incrustations on the bottom-land of the Santa Anna River, near San Bernardino ; in the soil along the Mojave River, Great Basin, and in the incrustation of the Soda Lake, at the end of the Mojave River. The last locality is the most important, and is an extensive deposit, but is not very thick. A portion of the crust taken from the lake gives a strongly alkaline solution, which contains:

Carbonate of soda.
Chloride of sodium.
Sulphate of magnesia, (trace.)
Carbonate of lime, (little.)

Efflorescences of soda, and crusts upon dry lakes, are common in Egypt, Asia, and elsewhere, in semi-desert regions.



T. SINCLAIR'S LITH. PHILA.

SECTIONS, SHEET I. ...
U.S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS
WAR DEPARTMENT
GEOLOGICAL SECTION
OF THE
SIERRA NEVADA AT THE TEJON PASS
Explored by Lieut. R. S. WILLIAMSON Corps of Topl. Engrs
1853
Prepared in the Office of Pacific Rail Road Explorations & Surveys
War Department
by William P. Blake.
S L O P E O F T H E T U L A R E V A L L E Y.
Alluvial and Lacustrine Clay
Detritus and Wash of gravel and sand probably underlaid by Tertiary strata
Hills of Tertiary strata
T E J O N
G R E A T B A S I N
Detrital deposits & Tertiary strata
Level of the Water at Suisun Bay at Benicia at mid tide
S L O P E O F T H E G R E A T B A S I N
Porphyry and Trap
Distant Hills probably granite
Level of the Water at Suisun Bay at Benicia at mid tide
Distant Hills probably granite
Erupted Porphyritic Rocks
B E D O F T H E D R Y L A K E
Granite
Granite traversed by large feldspathic veins
Level of the Water at Suisun Bay at Benicia at mid — tide

U.S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS
WAR DEPARTMENT

GEOLOGICAL SECTION ALONG THE TEJON RAVINE

Explored by Lieut. R. S. WILLIAMSON Corps of Topl. Engrs.
1853

FROM THE TULARE VALLEY AND THE TEJON DEPOT CAMP TO TAHEECHAYPAH PRAIRIE

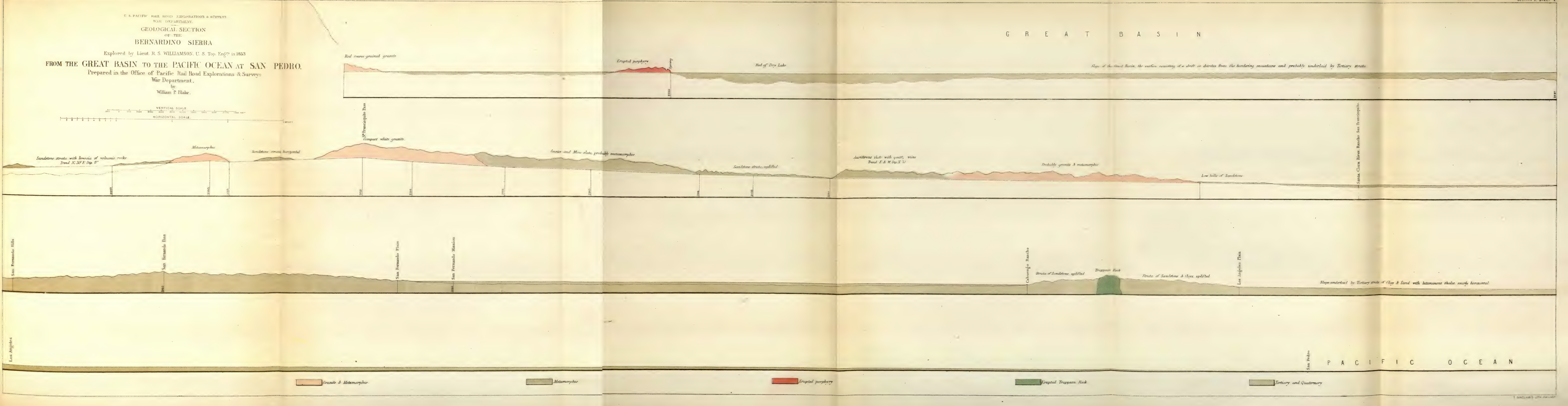
Prepared in the Office of Pacific Rail Road Explorations & Surveys
War Department
by William P. Blake.

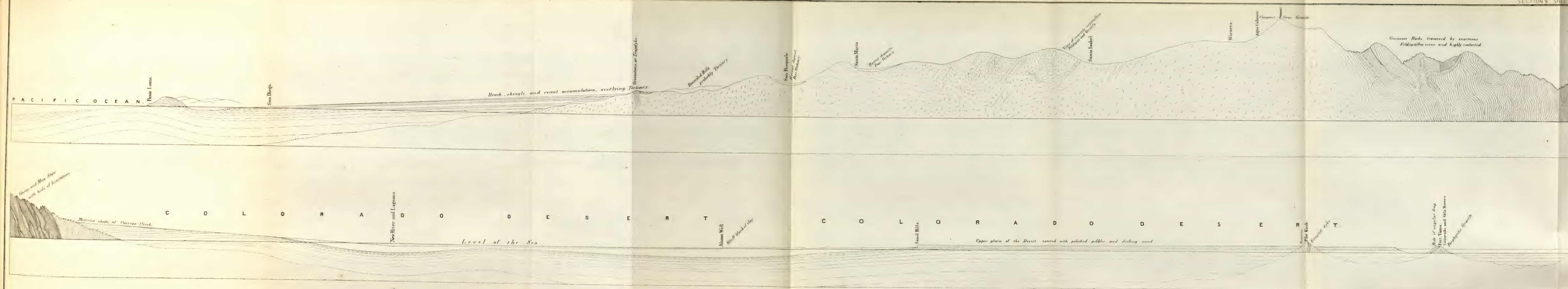
U.S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS
WAR DEPARTMENT

GEOLOGICAL SECTION OF THE SIERRA NEVADA AT THE CANADA DE LAS UVAS

Explored by Lieut. R. S. WILLIAMSON Corps of Topl. Engrs.
1853

Prepared in the Office of Pacific Rail Road Explorations & Surveys
War Department
by
William P. Blake.


U. S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS
WAR DEPARTMENT.
GEOLOGICAL SECTION
OF THE
BERNARDINO SIERRA
Explored by Lieut. R. S. WILLIAMSON, U. S. Top. Engrs in 1853
FROM THE GREAT BASIN TO THE PACIFIC OCEAN AT SAN PEDRO.
Prepared in the Office of Pacific Rail Road Explorations & Surveys
War Department,
by
William P. Blake.
VERTICAL SCALE.
HORIZONTAL SCALE.
MILES
GREAT BASIN
Red coarse grained granite
Erupted porphyry
Spring
Bed of Dry Lake
Slope of the Great Basin, the surface consisting of a drift or detritus from the bordering mountains and probably underlaid by Tertiary strata
Sandstone strata with breccia of volcanic rocks
Trend N. 30° E. Dip. 11°
Metamorphic
Sandstone strata horizontal
Sn. Francisquito Pass
Compact white granite
Gneiss and Mica slate, probably metamorphic
Sandstone strata, uplifted
Auriferous slate with quartz veins
Trend E. & W. Dip N. 70
Probably granite & metamorphic
Low hills of Sandstone
Santa Clara River, Rancho San Francisquito
San Fernando Hills
San Fernando Pass
San Fernando Plain
San Fernando Mission
Cahuengo Rancho
Strata of Sandstone, uplifted
Trappean Rock
Strata of Sandstone & Clays, uplifted
Los Angeles Plain
Slope underlaid by Tertiary strata of Clay & Sand with bituminous shales, nearly horizontal
Los Angeles
San Pedro
PACIFIC OCEAN
Granite & Metamorphic
Metamorphic
Erupted porphyry
Erupted Trappean Rock
Tertiary and Quaternary



U.S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS
WAR DEPARTMENT

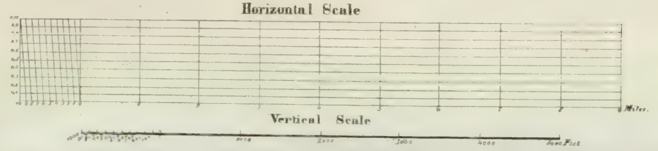
GEOLOGICAL SECTION FROM THE COLORADO RIVER TO THE PACIFIC OCEAN

Explored by Lieut. R. S. WILLIAMSON Corps of Topl. Engrs.

1853

Constructed from observations in the vicinity of the route from the mouth of the Gila river
Over the Colorado Desert and the Peninsula Sierra to San Diego via Carrizo Creek Vallecitos,
San Felipo, Warner's Pass, Santa Isabel and San Pasquale
Prepared in the Office of Pacific Rail Road Explorations & Surveys.
War Department
By William P. Blake.

1	Alluvial Deposits.
2	Tertiary Strata, and Cretaceous!
3	Erupted Greenstone.
4	Gneissose, Metamorphic.
5	Compact Granite.
6	Granitic veins.



1 Granite, Gneiss, Mica Slate

2 Tertiary

3 Drift, probably concealing Tertiary Strata

4 Alluvium

U. S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS.
WAR DEPARTMENT.

GEOLOGICAL SECTIONS

OF THE

BERNARDINO PASS

EXPLORED BY
LIEUT. R. S. WILLIAMSON CORPS TOP. ENG.RS
in 1853
Prepared in the Office of Pacific Rail Road Exploration and Survey
WAR DEPARTMENT
BY
WILLIAM P. BLAKE

SECTION 13, SHEET VIII.

SECTIONS 12, 13 & 14. PLATE VIII.

SECTION
ACROSS THE COLORADO RIVER ALONG THE CHANNEL OF NEW RIVER TO THE VALLEY OF THE ANCIENT LAKE

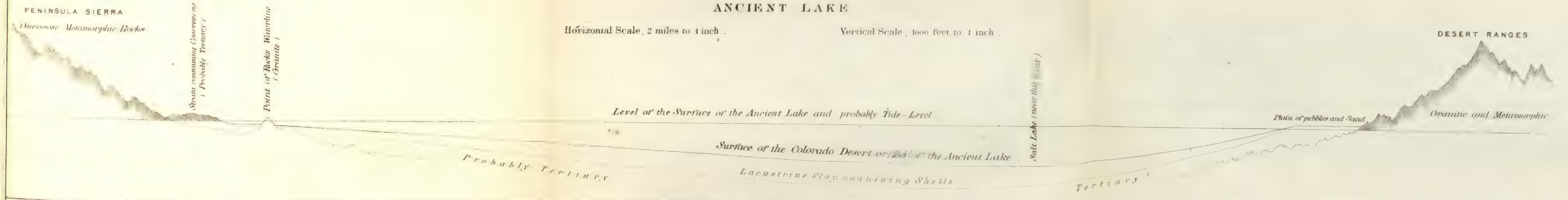
showing the probable elevation of the banks of the stream.

SECTION 12. SHEET VIII.

SECTION
OF THE
COLORADO DESERT
on a line extending northeast from the waterline on the point of rocks showing the probable depression of the valley of the

ANCIENT LAKE

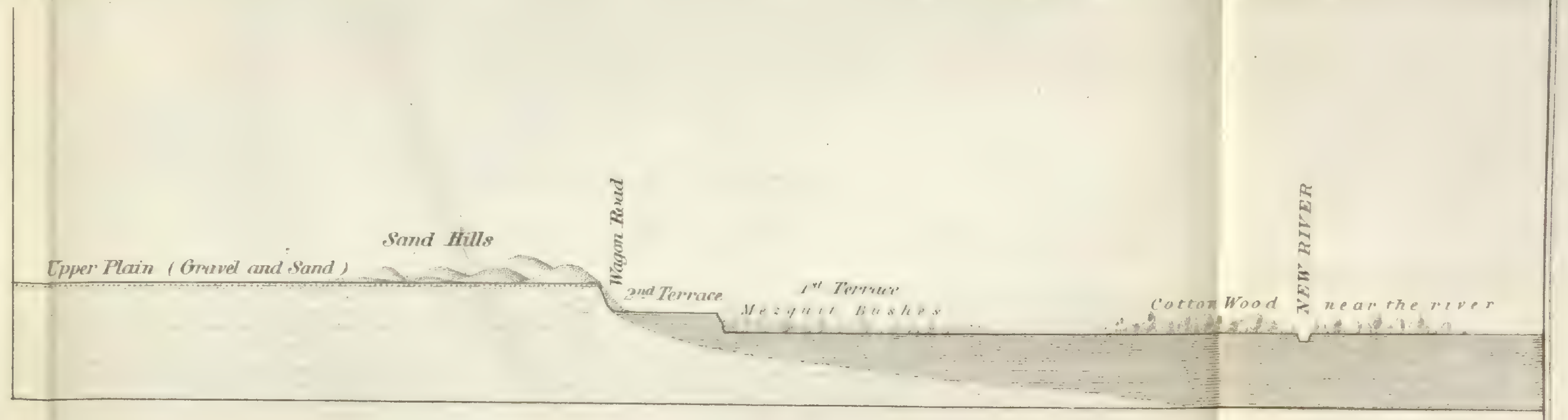
Horizontal Scale, 2 miles to 1 inch. Vertical Scale, 1000 feet to 1 inch.



SECTION 14.

SECTION
from North to South

SHOWING THE TERRACES AND SAND HILLS BETWEEN COOK'S WELL AND THE COLORADO RIVER



U. S. PACIFIC RAIL ROAD EXPLORATIONS & SURVEYS.
WAR DEPARTMENT.

SECTIONS OF THE COLORADO DESERT.

EXPLORED BY
LIEUT. R. S. WILLIAMSON CORPS TOP! ENG!!
in 1853.
Prepared in the Office of Pacific Rail Road Exploration and Survey.
WAR DEPARTMENT
BY
WILLIAM P. BLAKE.

Sarony, Major & Knapp Lith.

O R E G O N T E R R.
EXPLORATIONS AND SURVEYS FOR A R.R. ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.
WAR DEPARTMENT
GEOLOGICAL MAP OF A PART OF THE STATE OF CALIFORNIA
EXPLORED IN 1855 BY LIEUT. R. S. WILLIAMSON U.S. TOP. ENGR.
Prepared to accompany the report of WILLIAM P. BLAKE GEOLOGIST OF THE EXPEDITION.
Lith. of Sarony, Major & Knapp N.Y.
GREAT BASIN
SIERRA NEVADA
PACIFIC OCEAN
NEW MEXICO
Granitic and Metamorphic
Erupted Granite and Syenite
Serpentine, Trap, Greenstone and Porphyry
Basaltic Lava (Found in a table Land or Plateau at Fort Miller and at many points further north not represented on the map)
Metamorphic Slates, chiefly Clay Slate & Talcose Slate (Auriferous)
White and crystalline Limestone (Metamorphosed)
Tertiary and Quaternary (The wash and detritus or drift of the Great Basin and the Coast slopes generally rests upon or conceals Tertiary Strata)
Tertiary (Horizontal strata at Ocoya Creek but upraised at other localities. Includes the San Francisco Sandstone)
Alluvium (Lacustrine Clay of the Colorado Desert and of the Tulare Valley)
San Francisco
Sacramento
Stockton
Monterey
Los Angeles
San Diego
Santa Barbara
Mariposa
Marysville

APPENDIX.

APPENDIX.

ARTICLE I.

NOTICE OF THE FOSSIL FISHES.

BY PROFESSOR LOUIS AGASSIZ.

Most of the fossil remains of fishes, placed in my hands by Mr. Blake for examination and identification, belong to the family of sharks; one belongs to that of skates, and another is remotely allied to the family of mackerels. No fossil sharks' teeth having been found west of the Rocky mountains before, the discovery by Mr. Blake of a variety of species belonging to several genera of the family of sharks, constitutes one of the most interesting additions to our knowledge that could have been obtained from that quarter; and the importance of these fossils to science is further enhanced by the peculiar relations they bear to similar fossils found in the Atlantic States and in Europe, and to the sharks now living along the shores of the Old and of the New World.

ECHINORHINUS, *Blainv.*

1. E. BLAKEI, Agassiz, Pl. I, figs. 7, 8, 17.—The most interesting and important discovery, since the publication of the Poissons Fossiles, is that of the tooth of the genus Echinorhinus in the tertiary deposits of Ocoya creek, (Posé creek,) at the western base of the Sierra Nevada, California. The genus Echinorhinus was founded by Blainville for the *Squalus Spinosus* of Linnæus, the only species of the genus, thus far known, which inhabits the Mediterranean, and the European and African coasts of the Atlantic. I figured the teeth of the same genus under the name of Goniodus for the same species, (see Poissons Fossiles, vol. iii, p. 94, pl. E, fig. 13,) so that this name must give way to the Echinorhinus of Blainville. The discovery of the fossil species of this genus in the Tertiaries of the western slope of the Sierra Nevada is not only important as carrying back this curious type of sharks to a period older than ours, but also in disclosing the existence upon the American continent of types in a fossil state, known in the Old World only among the living. The fossil species of Echinorhinus differs from the living; having the main point of the tooth more prominent, and at the same time shorter; an appearance which arises from the less prominence of the marginal denticles. This difference may be distinctly seen by comparing the figures (Pl. I,) with those of the living species given in Poissons Fossiles, Pl. E, fig. 13.

SCYMNUS, *Cuv.*

2. S. OCCIDENTALIS, Agassiz, Pl. I, figs. 9–13.—The few species upon which Cuvier founded the genus Scymnus have been of late subdivided by Müller and Henle into two genera—Scymnus proper, and Læmargus—all of which are only known among the living. It is another of the highly interesting discoveries of Mr. Blake to have brought home two teeth from the Tertiaries of California belonging to this remarkable type. I would even not hesitate to consider them as indicating a distinct genus, were the number of specimens sufficient to warrant the inference that the teeth present in every position of mouth as great a difference from the true Scymnus and Læmargus as the two latter present when compared with one another. At all events, these teeth belong to the genus Scymnus, as established by Cuvier, and constitute a very distinct species, on account of the strong bend backwards of the main point of the tooth, and the distinct, and rather marked serration of the edges of the crown. Moreover, the inclination of the central point upon its basis gives these teeth a certain resemblance to those of Spinax and Centrophorus, and still more with Galeocerdo. The connexion of the teeth of the same row of the jaw with one another, was evidently the same as in the Scymnus and Læmargus, as is plainly shown, by the notch upon the inner surface of the root, and the articulating tubercle at the base of the enamel in both sides. The discovery of a fossil Scymnus in the Tertiaries of California is particularly interesting in a geographical point of view, since thus far no representative of the type has been found in the Pacific ocean.

GALEOCERDO, *Müller and Henle.*

3. G. PRODUCTUS, Agassiz, Pl. I, fig. 1–6.—Two species only, of living Galeocerdo have been known thus far; one from the Indian ocean, and one from the Atlantic. The fossil species have been traced from the chalk to the upper Tertiaries.

The Atlantic States have already yielded satisfactory indication of the presence of this genus, during the tertiary period, on the eastern coast of America. Now we receive from the collection of Mr. Blake a new addition to the range of this remarkable genus. The new species he has discovered resembles so closely the *Galeocerdo adoncus* from the Eocene of Europe, and especially common in the molasse of Switzerland, that were there not several specimens in the collection, agreeing with one another in every respect, and unitedly differing from those of the Old World, I would have been at a loss to distinguish them.

The California species differs chiefly from the European in having the anterior margin of the tooth less arched, with much more minute crenulations, and the serratures on the basilar margin rather smaller.

PRIONODON, *Müller and Henle.*

4. P. ANTIQUUS, Agassiz, Pl. I, figs. 15, 16.—Thus far no fossil shark of the tribe of Carcharias has been known among the fossils; and, as shown in the Poissons Fossiles, all the species formerly referred to the genus Carcharias have been ascertained to belong to the genus Carcharodon. Few discoveries in this field could, therefore, be of more interest than finding among the tertiaries of Ocoya creek a number of teeth agreeing in the deep notch upon the base of the root, but differing in their width as well as in the shape of their edge; belonging evidently to the genus Prionodon of Müller and Henle. The larger and broader ones having the edges serrated especially near the base, while the narrow ones are smooth and sharp. These

differences correspond exactly to the differences observed by Müller and Henle between the same species of the genus Prionodon. A transverse section of the fossil under consideration shows, moreover, these teeth to have a central cavity, as in those of the whole tribe of Carcharias. There can, therefore, be no doubt that we have here the first instance of a fossil species of the type of Carcharias, of the genus Prionodon, which it will be possible under all circumstances to distinguish from Sphyrna by the difference in the shape and serrature of the tooth in the upper and lower jaw. The species may be designated under the name of *Prionodon antiquus.* My *Galeocerdo denticulatus* from Maestricht may, however, belong to this genus. The tooth of this species being rather erect, while in Galeocerdo the crown of the tooth is bent backward, and its posterior margin is deeply notched. In *Prionodon antiquus,* as well as in G. denticulatus, the crown is but slightly inclined backwards, and though it tapers rapidly to a conical point, that point does not stand so distinctly out from its base, as in true Galeocerdo.

HEMIPRISTIS, *Agassiz.*

5. H. HETEROPLEURUS, Agassiz, Pl. I, fig. 14.—The genus Hemipristis was established by me from fossil teeth of the middle tertiaries of Europe. Dr. R. W. Gibbes has since indicated their existence among the tertiaries of the Atlantic shores of America, and now we owe to Mr. Blake the discovery of a tooth of this genus in the deposits of Ocoya creek, California. I have already remarked how difficult it is to perceive the difference existing between Galeocerdo adoncus of Europe and the species of that genus existing in California. I am still more doubtful about the propriety of distinguishing the species of Hemipristis of the west from those of Europe. It would seem extraordinary, however, to find the same species of sharks extending from the Pacific coast of this continent to central Europe, especially when we find upon closer examination our living sharks more closely circumscribed within narrow limits than was formerly supposed. And yet all the differences I perceive between the Hemipristis of California and those of Europe. consist in a marked irregularity between the serrature of the hinder margin, when compared with that of the anterior margin of the tooth. As this may be found to be a constant character, I would introduce the western species provisionally under the name of H. heteropleurus, or until the discovery of more specimens decides whether this difference in the serrature of the margin of the inner sides of the teeth is constant or not.

CARCHARODON, *Smith.*

6. C. RECTUS, Agassiz, Pl. I, figs. 39–41.—Of all the types of sharks' teeth, that of Carcharodon, next to Lamna and Oxyrhina, is the most numerous in the Tertiary deposits, though there is only one living species known. Mr. Blake has brought a finely preserved specimen of a medium sized species of this genus from California. Rather smaller than *Carcharodon angustidens,* the tooth has the same form as that species, only that there are no accessary points upon the sides of the base. Considering its size, this tooth is remarkable for its thickness; and in that respect it reminds me more of *Cacharodon angustidens* than any other species. The surface is flat, and the tooth straight, as in *C. angustidens,* and to this character the name *rectus* is intended to allude. Several species of this genus have been described by Dr. R. W. Gibbes, as occurring in the Tertiary of the Atlantic States.

OXYRHINA, *Agassiz.*

7. O. PLANA, Agassiz, Pl. I, fig. 29, 30.—Since the teeth of Oxyrhina are known to differ in size, so widely as they do, in the different parts of the jaw, nothing is more difficult than to

combine fossil teeth found separated, in such a manner as to leave no doubt about their specific identity. Several teeth of a very interesting species of Oxyrhina are found among the specimens of fossils brought by Mr. Blake from California, and its resemblance to the O.
of the Mediterranean is very striking. But, the character by which they differ most strikingly from the living species, and the fossils already described, consists in the greater flatness of the teeth, as compared with their width. Some of these are straight, and others slightly bent backwards. This species I propose to name *O. plana*. Several species of this genus have been described from the Atlantic States by Dr. R. W. Gibbes.

8. O. TUMULA, Agassiz, Pl. I., figs. 26, 27, 36, 37, 42–44.—The existence of a second species of the genus Oxyrhina in the Tertiaries of California is indicated by several teeth remarkable for the size and thickness of the roots, as compared with the length of the crown. The specimens agreeing in this character differ greatly in size, and yet not more so than may be seen in the same jaw of our living species. Found with the preceding by Mr. Blake.

LAMNA.

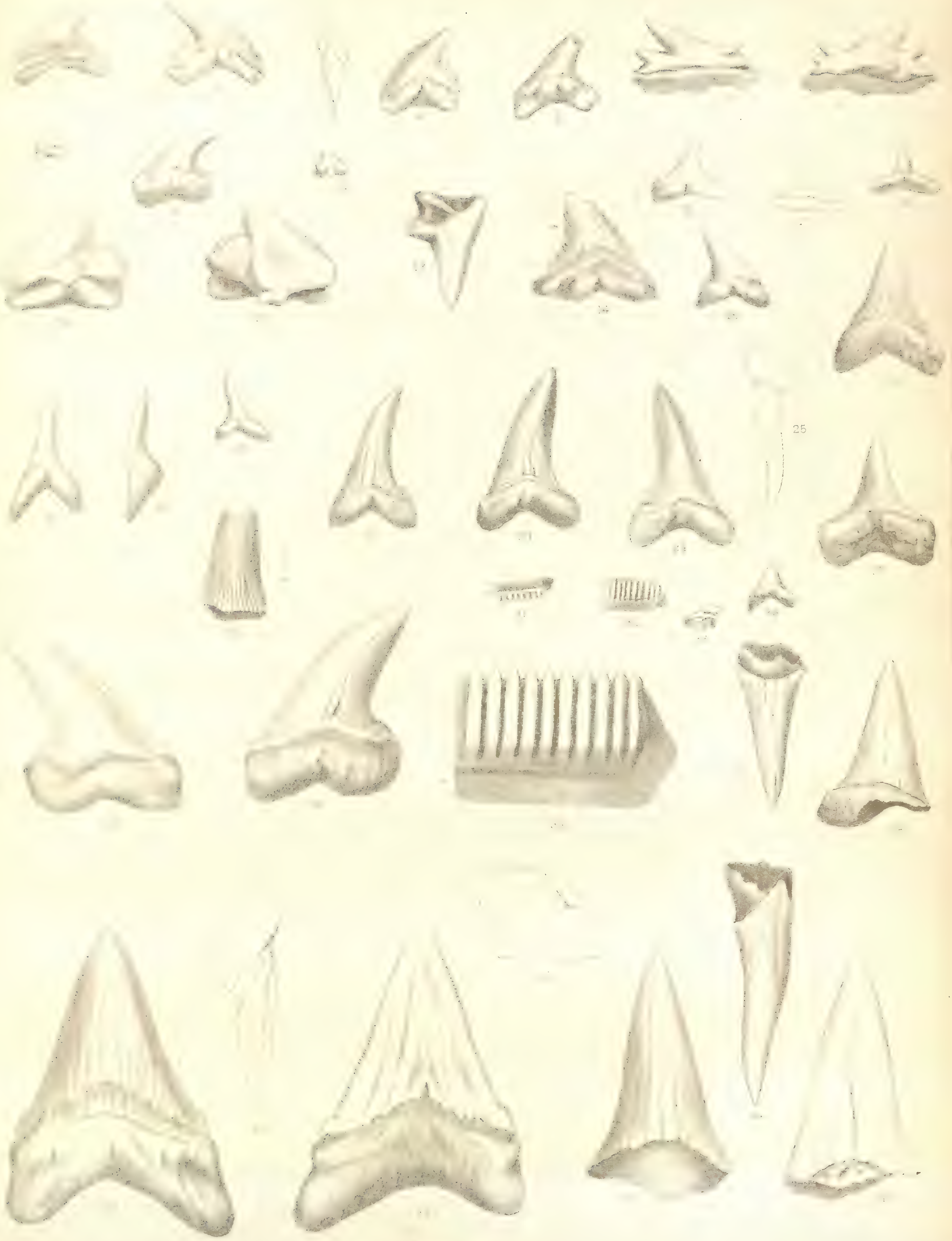
9. L. CLAVATA, Agassiz, Pl. I, figs. 19, 20, 21.—Two teeth from Ocoya creek indicate the existence in California of a species of Lamna allied to *L. cuspidata* of the European Miocene, from which it differs, however, by its smaller size, its shorter and narrower crown, in which respect it agrees more with *L. Hopei* of Sheppy. The crown, however, is less arched than in the latter. The posterior surface is smooth, as in *L. cuspidata*. Found with the preceding in the Tertiary formation of Ocoya creek.

10. L. ORNATA, Agassiz, Pl. I, fig. 28.—A second species of Lamna has been brought from California by Mr. Blake. It occurs in the sandstone of Navy Point, Benicia, and is allied to *L. elegans*, Agassiz.—(See Recherches sur les Poissons Fossile, vol. 3, p. 289.) It is, however, a smaller species, and tapers more gradually; while in *L. elegans* it tapers more suddenly near the top, and the folds of the enamel on the inner side of the tooth are coarser. The base of the tooth is more compressed than in *L. elegans*, in which respect the tooth resembles more *L. acuminata*. The small tooth found with the specimen may be one of the lateral teeth of the same species; but it is difficult to determine this without a microscopal examination of its structure. These fossils are unquestionably of Tertiary age. *L. elegans* is found in the Calcaire grossier, in the environs of Paris, and in the London clay at Sheppy. The same species is also found fossil in the Crag, having been transported with the remains of many other species from the London clay. Several species of this genus have been described from the Atlantic States by Dr. R. W. Gibbes.

ZYGOBATES, *Agassiz.*

11. ZYGOBATES ——— ? Pl. I, fig. 31–35. A fragment of a tooth of the genus Zygobates is interesting, inasmuch as it shows that this genus of the order of the family of Skates with pavement-like teeth to have occurred in California during the Tertiary period; though the fragment of the tooth before me is too imperfect to allow the species to be identified. It may not be out of place to remark that no species of this genus or the allied genera Rhinoptera, Ætobates, or Myliobates, have thus far been found in the Pacific ocean.

Several fragments of bone found with the teeth at Ocoya creek (Posé creek) belong to the family of Scomberoides, but are too imperfect to admit of being identified.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ARTICLE II.

DESCRIPTIONS OF THE FOSSIL SHELLS.[1]

BY T. A. CONRAD.

PHILADELPHIA, PA., *January*, 1855.

SIR: I have examined the very interesting organic remains which you collected in California, and the drawings of such species as were too fragile to preserve, and I herein submit a few remarks upon their geological relations. There appear to be several distinct groups; but I cannot pretend, from such scanty materials, to designate what particular formation every group represents. There is no obscurity resting on the deposits of Santa Barbara and San Pedro, which represent a recent formation, in which you inform me the remains of the mammoth occur. The shells are generally those which live in the adjacent waters, and indicate little, if any, change of temperature since their deposition. The littoral character of this formation is very evident. Water-worn shells and fragments show the action of the surf, whilst entire specimens of bivalves, and Pholadidæ, and Saxicavæ, remaining undisturbed in their self-excavated domicils, exhibit the same disposition of marine shells that is familiar to the observer on all sandy and argillaceous shores. They burrow in clay, mud, or sand, beyond the ordinary action of the surf; whilst some are scooped out by the tempest-driven surge, and others preyed upon by fishes and marine animals of various kinds, and are thus broken up and deposited among the living species.

Of the Eocene, and the recent formation alluded to, I can speak with confidence; but the intermediate beds are of uncertain age. The *Ostrea vespertina*, *Anomia subcostata*, and *Pecten deserti*, occurring in the bank of Carrizo creek, are unlike any recent forms that I am acquainted with from the Pacific coast, but analagous to Miocene species of Virginia. This formation may, therefore, be regarded as of Miocene origin—an opinion in which I am confirmed by some fossils collected in California by Dr. Heermann, consisting of decidedly Miocene forms; a *Mercenaria*, (*M. perlaminosa*,) Con., scarcely differing from a species of Cumberland county, N. J., (*M. Ducatelii*, Con.,) a *Cemoria*, *Pandora*, and *Cardita* of extinct species, closely analogous to Miocene forms. I am inclined, also, to refer to this period a very different group from Ocoya creek, the forms of which you sketched in California, as the specimens were too friable to be preserved. I do not recognise any recent species among them, nor any contained in an Eocene deposit.

The rock at San Diego is replete with shells, generally of a small size, and appears to have a certain palæontological relation to those of Monterey, Carmello, and those in boulder specimens of Oregon, collected by Townsend and Dana, which I have referred to the Miocene period. Two species of San Diego, if not identical, approach Oregon shells; *Nucula decisa* is similar to *N.*

[1] These descriptions were published in 1855. See the Appendix to the Preliminary Geological Report, 8vo; Washington, 1855.

divaricata, and both, in their markings, resemble *N. cobboldii* of the English Miocene. *Mactra Diegoana* is nearly related to the Oregon *M. albaria*.

The Eocene period is unequivocally represented by the beautifully perfect shells from the Cañada de las Uvas, which, though not found in situ, are evidently derived from strata occurring on the Pacific slope of the Sierra Nevada. This is very remarkable, inasmuch as three species correspond with forms of Claiborne, Alabama, and seem to indicate a connexion of the Atlantic and Pacific oceans during the Eocene period. The vast distance between the two localities will account for the general distinction of species, and it was, indeed, an unexpected result to find any identical. If I had imagined any eastern species to occur in California, it would have been the very one which does occur, and, apparently, in abundance, that "finger-post" of the Eocene, *Cardita planicosta*, a fossil of the Paris basin, and also abundant in Maryland, Virginia, and Alabama. This species originated and perished in the Eocene period, and is so widely distributed that it may be regarded as the most characteristic fossil of its era. As the boulder from which these shells were derived was quite small, and yet furnished thirteen species, when it shall be investigated in situ, doubtless a great many other forms will be obtained, and very likely some with which we are already familiar in eastern localities. Although the rock is a very hard sandstone, the shells may be exposed in great perfection by careful management, and we look forward with great interest to their further development, and to the discovery of the rock in situ.

Respectfully, yours, &c.,

T. A. CONRAD.

WM. P. BLAKE, *Geologist of the United States Pacific Railroad Survey in California.*

CATALOGUE.

I. EOCENE.

No.	Name.	Locality.
1	Cardium linteum, (nova species.) Con	Cañada de las Uvas
2	Dosinia alta, (nov. sp.) Con	do
3	Meretrix Uvasana, (nov. sp.) Con	do
4	——— Californiana, (nov. sp.) Con	do
5	Crassatella Uvasana, (nov. sp.) Con	do
6	——— alta, Con	do
7	Mytilus humerus, (nov. sp.) Con	do
8	Cardita planicosta	do
9	Natica œtites. Con	do
10	——— gibbosa. Lea	do
11	——— alveata	do
12	Turritella Uvasana, (nov sp.) Con	do
13	Volutatithes Californiana, (nov. sp.) Con	do
14	Busycon? Blakei, (nov. sp.) Con	do
15	Clavatula Californica, (nov. sp.) Con	do

CATALOGUE—Continued.

II. MIOCENE AND RECENT FORMATIONS.

No.	Name.	Locality.
16	Cardium modestum, (nov. sp.) Con	San Diego
17	Nucula decisa, (nov. sp) Con	do
18	Corbula Diegoana, (nov. sp.) Con	do
19	Meretrix uniomeris, (nov. sp.) Con	Monterey county
20	——— decisa, (nov. sp.) Con	Ocoya creek
21	——— Tularena, (nov. sp) Con	Tulare valley
22	Tellina Diegoana, (nov. sp.) Con	San Diego
23	——— congesta, (nov. sp.) Con	Monterey, Carmello, and San Diego
24	——— Pedroana, (nov. sp.) Con	San Pedro
25	Arca microdonta, (nov. sp.) Con	Tulare valley?
26	Tapes diversum	San Pedro
27	Saxicava abrupta, (nov. sp.) Con	do
28	Petricola Pedroana, (nov. sp.) Con	do
29	Schizothœrus Nutalli, (nov. sp.) Con	do
30	Lutraria Traskei, (nov. sp.) Con	Carmello
31	Mactra Diegoana, (nov. sp.) Con	San Diego
32	Modiola contracta, (nov. sp.) Con	Monterey county
33	Mytilus Pedroanus. (nov. sp.) Con	San Pedro
34	Pecten Deserti, (nov. sp.) Con	Colorado desert
35	Anomia subcostata, (nov. sp.) Con	do
36	Ostrea vespertina, (nov. sp.) Con	do
37	——— Heermanni, (nov. sp.) Con	do
38	Penitella spelæa, (nov. sp.) Con	San Pedro, (recent.)
39	Fissurella crenulata. Sow	do
40	Crepidula princeps, (nov. sp.) Con	Santa Barbara
41	Narica Diegoana, (nov. sp.) Con	San Diego
42	Trochita Diegoana, (nov. sp.) Con	do
43	Crucibulum spinosum, (nov. sp.) Con	do
44	Nassa interstriata, (nov. sp.) Con	San Pedro
45	—— Pedroana, (nov. sp.) Con	do
46	Strephona Pedroana, (nov. sp.) Con	do
47	Littorina Pedroana, (nov. sp.) Con	do
48	Stramonita petrosa, (nov. sp.) Con	Tulare valley
49	Gratelupia mactropsis, (nov. sp.) Con	Isthmus of Darien
50	Meretrix Dariena, (nov. sp.) Con	do
51	Tellina Dariena, (nov. sp.) Con	do
52	Natica Ocoyana, (nov. sp.) Con	Ocoya or Posè creek
53	——— geniculata, (nov. sp.) Con	do
54	Bulla jugularis, (nov. sp.) Con	do
55	Pleurotoma transmontana, (nov. sp.) Con	do
56	——— Ocoyana, (nov. sp.) Con	do
57	Syctopus Ocoyanus, (nov. sp.) Con	do
58	Turritella Ocoyana, (nov. sp.) Con	do
59	Colus arctatus, (nov. sp.) Con	do
60	Tellina Ocoyana, (nov. sp.) Con	do
61	Pecten Nevadanus, (nov. sp.) Con	do

CATALOGUE—Continued.

No.	Name.	Locality.
62	——— catilliformis, (nov. sp.) Con	Ocoya or Posé creek
63	Cardium ——— ?	do
64	Arca ——— ?	do
65	Solen ——— ?	do
66	Dosinia ——— ?	do
67	Venus ——— ?	do
68	Cytherea decisa ? Con	do
69	Ostrea ——— ?	San Fernando
70	Pecten ——— ?	do
71	Turritella biseriata, (nov. sp. ?) Con	do
72	Trochus ——— ?	Benicia
73	Turritella ——— ?	do
74	Buccinum interstriatum ?	San Pedro
75	Anodonta Californiensis. Lea	Colorado desert

DESCRIPTIONS OF FOSSIL SHELLS FROM THE EOCENE AND MIOCENE FORMATIONS OF CALIFORNIA.

I. EOCENE.

CARDIUM, *Lin.*

1. C. LINTEUM, Conrad, Pl. II, fig. 1.—Cordate, ventricose subequilateral, with closely arranged radiating lines, umbonal slope subcarinated ; posterior submargin with closely arranged smooth striæ, fine, but much larger than those of the disk.

Locality.—Cañada de las Uvas. Allied to *C. Nicolleti*, Con., but very distinct.

DOSINIA, *Scopoli.*

2. D. ALTA, Con., Pl. II, fig. 2.—Elevated equilateral? posterior side short ; disk with fine closely arranged concentric lines, becoming large towards the base ; posterior extremity obtuse, direct.

Locality.—Cañada de las Uvas, with the preceding.

MERETRIX, *Lam.* CYTHEREA, *Lam.*

3. M. UVASANA, Con. Pl. II, fig. 3.—Suboval convex, inequilateral, margins rounded ; beaks distant from anterior margin ; disk with concentric, rather distant ribs, which were probably laminiform when perfect.

Locality.—Cañada de las Uvas.

There is but one broken valve of this species, in hard sandstone and with the ribs broken off.

4. M. CALIFORNIANA, Con., Pl. II, fig. 4.—Subcordate, ventricose, inequilateral ; posterior extremity truncated somewhat obliquely inwards ; basil margin nearly straight in the middle ; lunule lanceolate ; anterior extremity acutely rounded.

Locality.—Occurs at the Cañada de las Uvas, with the preceding species. Allied to *M. Poulsoni*, Con.

CRASSATELLA, *Lam.*

5. C. UVASANA, Con., Pl. II, fig. 5.—Subtriangular, compressed, concentrically sulcated above,

and having a few slight concentric undulations inferiorly; ligament slope very oblique, rectilinear, anterior extremity regularly rounded.

Locality.—Cañada de las Uvas, with the preceding species.

6. C. ALTA, C nrad.—This species occurs in the same rock with the preceding, but only in small fragments. It appears to have been abundant, as it likewise is at Claiborne, Alabama. The fracture has resulted from breaking the rock, as the shell appears to have been perfect and not water-worn.

MYTILUS, *Lin.*

7. M. HUMERUS, Con., Pl. II, fig. 10.—Ovate, ventricose, summit acute; anterior margin rectilinear; basal margin rounded; anterior extremity less obtuse; disk with minute radiating lines.

Locality.—Cañada de las Uvas, with the preceding fossils.

CARDITA, *Brug.*

8. C. PLANICOSTA, Pl. II, fig. 6.—Obliquely cordate; ribs about 22, broad and flattened, separated by a narrow groove which becomes obsolete towards the base; ribs on the posterior slope narrow, indistinct, and crossed by numerous profound wrinkles. Lunule small, cordate, profoundly impressed; inner margine crenate.

Locality.—Cañada de las Uvas, with the preceding fossils. *Venericardia planicosta Lam. An. Sans Vert.* (Desh. ed.) vol. vi., p, 381.

This common species occurs much larger, though less perfect, than the one represented. This shell occurs abundantly in the Eocene strata of Maryland, Virginia and Alabama, and is quite as characteristic of the American as of the European Eocene period. I discovered it in Maryland in 1829, and at that time regarded it as the first indication of the occurrence of deposits in the United States synchronous with those of the London clay. Prof. Rogers has since named this shell *Venericardia ascia.*

NATICA, *Adamson.*

9. N. ŒTITES? Con., Pl. II, fig. 7.

Locality.—Cañada de las Uvas, with the preeeding fossils.

N. œtites., Conrad.—*Foss. shells of Tert. Form. October*, 1833.

10. N. GIBBOSA and SEMILUNATA, Lea. *Cont. to Geol. December*, 1833.—There is but one specimen of this shell, which I refer with doubt to a Claiborne species. The outline is similar to that of the latter, but the aperture is concealed in the rock, which prevents the necessary comparison to determine the identity or the difference.

11. N. ALVEATA, Con., Pl. II, fig. 8 and 8*a*.—Volutions 5, flattened above, carinated on the angle, a few minute obsolete lines revolve on the upper side of the whorls; aperture inclining to an obovate form; umbilicas small.

Locality..—Cañada de las Uvas.

This species is remarkable for its truncated whorls, which are channelled by the carina on the margin. There are no analogous species in the Eocene of the Atlantic slope.

TURRITELLA, *Lam.*

12. T. UVASANA, Con., Pl. II, fig. 12.—Subulate, whorls with the sides straight and oblique above, rounded below, and having large revolving striæ with intermediate minute lines; striæ near the suture on the upper part of the whorls finer than the prominent lines below.

Locality.—Occurs with the preceding, in Cañada de las Uvas.

This species is allied to *T. obruta*, Conrad, (*T. lineata*, Lea.,) but that Claiborne shell differs in having fewer revolving lines, and in being indented at the suture.

VOLUTATITHES, *Swains.*

13. V. CALIFORNIANA, Con., Pl. II, fig. 9.—Resembles *V. Sayana*, Con,, but smaller, having numeraus rounded tubercles instead of the comparatively few spiniform ones of the latter. The tubercles are somewhat oblique ; base with rather distant impressed lines.

Locality.—Cañada de las Uvas, with the preceding.

BUSYCON?

14. B.? BLAKEI, Con., Pl. II, fig. 13.—Fusiform, body whorl bicarinated; shoulder profoundly tuberculated; tubercles acute, transversely compressed; lower angle distant, entire. Surface covered with rather fine unequal or alternated wrinkled lines; upper side of the whorls flattened and sloping; whorls of the spire angulated and tuberculated in the middle.

Locality.—Cañada de las Uvas, with the preceding.

The beak of this shell being broken, its form and length are uncertain, and the aperture being concealed in the rock, the generic character can only be inferred from the contour of the shell. This corresponds with *Busycon*, except in the biangular form of the body whorl, in which respect it differs from any undoubted species that I have seen.

CLAVATULA? *Swains.*

15. C.? CALIFORNICA, Con., Pl. II, fig. 11.—Fusiform; spire conical, volutions rounded, somewhat flattened above; body whorl ventricose; beak short and narrow.

Locality.—Cañada de las Uvas, with the preceding. Allied to *C. proruta*, Con., of the Claiborne Eocene, but proportionably narrower.

II. FOSSILS OF THE MIOCENE AND RECENT FORMATIONS OF CALIFORNIA.

CARDIUM, *Lin.*

16. C. MODESTUM, Con., Pl. III, fig. 15.—Very small; ribs about 22, narrow; concentric wrinkled lines on the disk; posterior margin direct, truncated; umbonal slope angular; ligament margin parallel with the basal, and forming nearly a right angle with the posterior margin.

Locality.—San Diégo Mission.

NUCULA, *Lam.*

17. N. DECISA, Con., Pl. III, fig 19.—Suboval or sub-rhomboidal, posterior margin obliquely truncated; disk with devaricating striæ.

Locality.—San Diégo, with the preceding.

This species resembles, in its divaricating striæ, *N. divaricata*, of the Oregon Miocene; but the lines are proportionally larger, and the shell is smaller and different in outline.

CORBULA.

18. C. DIEGOANA, Con., Pl. III, fig. 16.—Triangular, ventricose, inequilateral, extremities subangulated; anterior margin very oblique, rectilinear; posterior margin forming with the

ligament margin a slightly curved line, about equal in obliquity to the anterior margin; basal margin profoundly and nearly equally or regularly rounded.

Locality.—Mission of San Diégo.

MERETRIX, *Lam.*

19. M. UNIOMERIS, Con., Pl. III, fig. 20.—Ovate, very inequilateral, convex; posterior side cuneiform; ligament margin very oblique, rectilinear; posterior extremity truncated, direct; beak distant from anterior margin.

Locality.—Monterey county, 18 miles south of Trés Piños, in sandstone.

20. M. DECISA, Con., Pl. III, fig. 27.—Subquadrate, convex, very inequilateral; ligament slope very oblique, nearly straight; posterior extremity truncated; cardinal and lateral teeth robust. [Cast.]

Locality.—Ocoya creek, in friable ferruginous coarse sandstone. [For the associate fossils, see plates vii, viii, and ix.]

21. M. TULARANA, Con., Pl. III, fig. 22 and 22*a*.—Suboval or subtriangular, inequilateral convex anteriorly; compressed and cuneiform posteriorly, anterior extremity acutely rounded and as nearly in a line with the beak as the base; basal margin tumid medially; posterior extremity subtruncated.

Locality.—Tulare valley.

[NOTE.—This specimen is a clay cast, and was found in a boulder that had been washed down from the hills at the head of the Tulare valley, about twenty miles west of the Cañada de las Uvas. W. P. B.]

TELLINA, *Lin.*

22. T. DIEGOANA, Con., Pl. III, fig. 28.—Ovate-eliptical, compressed, inequilateral, concentrically striated. Slope carinated; posterior extremity suddenly produced or rostrated, and below the posterior basal margin.

Locality.—San Diégo, in sandstone.

23. T. CONGESTA, Con., Pl. III., fig. 14, 18, 21, and 21*a*.—Subtriangular, ventricose, inequilateral; anterior margin obliquely truncated; anterior basal margin sub-rectilinear, oblique, extremity angulated, much above the line of the base; posterior margin and posterior basal margin regularly rounded.

Localities.—Monterey; Mission of San Diégo; Carmello.

This interesting species is very abundant at Monterey, in indurated drab-colored clay. There is merely a chalky trace of the shell remaining. It occurs in a somewhat similar rock at Carmello, and in sandstone at San Diégo. Figure 14 is from San Diégo; 21 and 21*a* from Monterey; and 18 from Carmello.

24. T. PEDROANA, Con., Pl. III, fig. 17.—Subtriangular, inequilateral, compressed; anterior dorsal margin oblique, rectilinear; anterior extremity truncated, posterior margin regularly rounded, basal margin subrectilinear.

Locality.—San Pedro. Recent formation.

A thin smooth species, of which only one valve was obtained.

ARCA, *Lin.*

25. A. MICRODONTA, Con., Pl. III, fig. 29.—Rhomboidal, ventricose, thick in substance; anterior side very short; umbonal slope rounded. Ribs 25, prominent, narrow, wider posteriorly,

except on the posterior slope, where they are small and not prominent, about five in number. Cardinal teeth small, numerous, closely arranged, larger towards the extremities. Inner margin profoundly dentate; dorsal area rather wide and marked with about six impressed lines; beaks distant.

Locality.—Tulare valley? Miocene.

There is but one valve in the collection, and it has some resemblance to *A. arata*, Say, of the Maryland Miocene. The locality is given by Mr. Blake with a mark of doubt.

TAPES.

26. T. DIVERSUM, Sow., Pl. III, fig. 31, 31*a* and 31 *b*.—Obtusely oval or suborbiculary ventricose, inequilateral; disk with numerous radiating prominent striæ or ribs, and concentric wrinkled lines, which are profound anteriorly; posterior margin nearly direct, obtusely rounded or subtruncated; inner margin with small crenulations; ligament plate broad and profoundly indented.

Locality.—San Pedro, in calcareous marl. Recent formation.

SAXICAVA, *Fleur de Bell.*

27. S. ABRUPTA, Con., Pl. III, fig. 25 and 25*a*.—Suboval, ventricose, inequilateral; concentrically wrinkled; anterior margin obtusely rounded obliquely inwards; posterior extremity truncated, direct, dorsal and basal margin nearly parallel.

Locality.—San Pedro. Recent formation.

PETRICOLA, *Lam.*

28. P. PEDROANA, Con., Pl. III, fig. 24.—Elliptical, profoundly inequilateral, compressed, undulated concentrically, and with very minute closely-arranged radiating lines.

Locality.—Occurs with the preceding shell. Recent formation.

One broken valve of this species occurred in the same specimen of rock in which they had bored. Some specimens of the Saxicava are entire, and fill the cavities they have formed, when living.

SCHIZOTHŒRUS, *Conrad*

29. S. NUTTALLI, Con., Pl. IV, fig. 33 and 33*a*.—Ovate, ventricose, gaping widely posteriorly; moderately thick in substance; anterior side short, abruptly rounded at the extremity; posterior side elongated, extremely truncated; dorsal line slightly concave; umbo not prominent; basal margin profoundly rounded; hinge-plate broad, cartilage pit large, obliquely ovate, profound; cardinal teeth in the left valve two, one in the right valve; anterior cardinal plate broad, with an angular depression throughout its entire length, posterior one narrow, with a deep angular channel in which is a bifid plate in the right valve; cavity of shell and umbo profound.

Locality.—San Pedro is calcareous marl. Recent formation.

I have referred this shell to the same genus in which I placed *Lutraria Nuttalli* of the California coast. The hinge is very similar to that of *Lutraria*, but the long deep channels of the hinge are similar to those of *L. Nuttalli*, the animal of which differs from that of *Lutraria*. I do not know of any recent species of the latter genus in California.

LUTRARIA? *Lam.*

30. L. TRASKEI, Con., Pl. III, fig. 23.—Suboval, ventricose, inequilateral, hinge and basal margin nearly parellel; posterior margin subtruncated and slightly oblique, or approaching a direct outline; posterior extremity rounded.

Locality.—Carmello. Miocene? [Received from John B. Trask, by whom it was collected.—*W. P. B.*]

MACTRA, *Lin.*

31. M. DIEGOANA, Con., Pl. V, fig. 45.—Triangular ventricose, inequilateral, anterior side oblique, rectilinear; umbonal slope carinated and nearly terminal; basal margin profoundly and regularly rounded.

Locality.—San Diego. Miocene?

This species is nearly allied to *M. albaria* of the Oregon Miocene, which probably belongs to the same rock as the present species. The concentric ridges represented in the figure are caused by weathering, as the disk was originally smooth.

MODIOLA, *Lam.*

32. M. CONTRACTA, Con., Pl. V, fig. 35.—Elongated, narrowed, anteriorly, contracted submedially; basal margin widely contracted; disk with numerous minute radiating lines.

Locality.—Monterey Co., 16 miles S. of Trés Pinos. Recent formation.

A portionof the shell remains, showing traces of fine radiating lines. Miocene?

MYTILUS, *Lin.*

33. M. PEDROANUS, Con., Pl. V, fig. 40.—Oblong-subovate, ventricose, dorsal line ungulated medially, angle rounded; beak projecting slightly beyond the basal margin; posterior extremity rounded; basal margin rectilinear.

Locality.—San Pedro. Recent formation.

P CTEN, *Lin.*

34. P. DESERTI, Con.) Pl. V, fig. 41.—Suborbicular, both valves convex; ribs about 23, rounded, somewhat flattened toward the base, about as wide as the interstices, and the valve more convex than the opposite one; ears equal in the upper valve; left ear of lower valve extended downwards and very obliquely striated; cartilage pit profound; a submarginal channel parallel with the upper margin.

Locality.—Carrizo creek, Colorado desert. Miocene.

AOMA, *in.*

35. A. SUBCOSTATA, Con., Pl. V, fig. 34.—Obtusely ovate, thick in substance, umbo of larger valve ventricose, hinge thickened; surface of this value obtusely undulated, concentrically and marked with waved, wrinkled, very irregular interrupted ribs, not much raised except toward the base, where they are larger and somewhat tuberculiform, upper valve entire, or with obsolete radii toward the base.

Locality.—Carrizo creek, Colorado desert. Miocene.

Allied to *A. Ruffini* of the Virginia Miocene, but thicker, less expanded, and with the radii more numerous and more rib-like.

OSTREA, *Lin.*

36. O. VESPERTINA, Con., Pl. V, figs. 36. 37, 38.—Ovate, subfalcate, lower valve plicated or ribbed more or less profoundly; hinge long and wide, sharp and somewhat pointed; ligament cavity wide, profound, minutely wrinkled; margins abrupt; cavity not very deep; muscular impression large, impressed; upper valve flat, irregular, plicated on the margin; a submarginal furrow, slightly impressed, crenulated towards the hinge.

Locality.—Carrizo creek. Miocene.

O. vespertina. Con. *Jour. Acad. Nat. Sc.*, new series, vol. 2, part 4, p. 300.

This species is very similar in form and *plications* to *O. subfalcata*, Con., of the Virginia Miocene.

37. O. HEERMANNI, Con. *Acad. Nat. Sc.*, Philadelphia, Pl. , figs. .—Very irregular in form, ovate and often dilated; lower valve shallow; exterior very irregular, with large distant angular radiating ribs, and with pits and irregular cavities; cartilage pit broad and oblique; upper valve flat or concave, with a profoundly irregular surface. Length 5¾ inches, height 6½ inches.[1]

Locality.—Carrizo creek, Colorado desert. Dr. Heermann.

This large oyster shell probably belongs to the same deposit which contains *O. vespertina* and *Anomia subcostata.* The surfaces of most specimens have a resemblance to worm-eaten wood, having been evidently sculptured by some marine animal.[2]

PENITELLA.

38. P. SPELŒA, Pl. V, 43, 43*a*, 43*b*.—Ovate, ventricose, anteriorly inflated with fine radiating lines and transverse wrinkles, transverse furrow medial, angular, slightly oblique; posterior side cruneiform, truncated at the extremity, which is direct, and with prominent, acute, wrinkled concentric lines; front dorsal margin widely recurved, trisulcate; cardinal plate broad, sulcated process slender, direct.

Locality.—San Pedro. Recent formation.

No trace of the coriaceous cup, characteristic of this genus, remains in the collection. It is widely distinct rom the recent species of the California coast, *P. penita*, Conrad.

FISSURELLA, *Lam.*

39. F. CRENULATA, Sow., Pl. V, fig. 44.—Oblong subovate, slightly contracted laterally opposite the foramen. Shell with numerous radiating conspicuous compressed lines; foramen large, subovate, not nearly central; inner margin crenulated, thickened basal margin sinous; inner margin of foramen broadly callous; cavity profound.

F. crenulata, *Sowerby*, Tankerville catalogue.

Locality.—San Pedro. Recent formation. This is the largest fossil species I have seen.

CREPIDULA, *Lam.* CRYPTA, *Humph.*

40. C. PRINCEPS, Con., Pl. VI, fig. 52, 52*a*.—Oblong, ovate, thick and ponderous, contracted or compressed superiorly; upper side or portion of the shell sloping; back regularly rounded; beak prominent, rounded, laterally curved; apex distant from the margin of the aperture; diaphragm very large, with a very sinuous margin.

Locality.—Santa Barbara. Recent formation.

This is the largest species that has come under my observation, and is very distinct from any that has yet been described.

NARICA.

41. N. DIEGOANA, Con., Pl. V, fig. 39.—Subglobose, sides flattened; obtuse above.

Locality.—San Diego. Miocene?

Partially embedded in the rock and its form not accurately determined.

[1] The figures which are given in Plate — are from a smaller and more characteristic specimen than that of which the dimensions are given by Mr. Conrad. The specimen which is figured is, however, much worn and broken on the edges.

[2] These specimens were picked up by Dr. Heermann in the bed of the creek, and were undoubtedly derived from a portion of the stratum of shells that I found in situ. W. P. B.

TROCHITA, *Shum.*

42. T. DIEGOANA, Con., Pl. V, fig. 42.—Conical; volutions three, rounded smooth; body whorl ventricose.

Locality.—Occurs with the preceding. Miocene?

CRUCIBULUM, *Shum.*

43. C. SPINOSUM, Con., Pl. V, fig. 46, 46*a*.—Moderately elevated, suboval, armed with numerous prominent spines in radiating series; spines smaller, and the series more closely arranged anteriorly; apex sub-central? prominent acute; shell with concentric wrinkles.

Calyptræa spinosa?—Sowerby.

Locality.—San Diego? Recent on the coast of Peru.

NASSA, *Lam.*

44. N. INTERSTRIATA, Con., Pl. VI, fig. 49.—Ovate-acute; whorls 5½, rounded, cancellated; longitudinal striæ nodulous, except towards the base of the body whorl; a deep sulcus behind the beak, two upper volutions entire; labrum striated within; spire conical, longer than the aperture.

Locality.—San Pedro. Recent formation.

The surface of this shell is roughened by a tubercle on the longitudinal, at each intersection of the revolving lines.

45. N. PEDROANA, Con., Pl. VI, fig. 48.—Subfusiform, smooth; volutions rounded, spire conical, longer than the aperture, which is elliptical; columella very regularly concave.

Locality.—Occurs with the preceding. Recent formation.

This small species resembles *Nassa lunata*, Say, as the preceding approximate *N. trivittata*, Say. This is very remarkable, as the two latter are recent shells of the Atlantic coast, associated with each other, both in the sea and in the Miocene deposits of Virginia and Maryland.

STREPHONA, *Browne.* OLIVA, *Lam.*

46. S. PEDROANA, Con., Pl. VI, fig. 51.—Small, elliptical; spire conical, about equal in length to the aperture; base of calumella with a prominent fold.

Locality.—Occurs with the preceding. Recent formation.

A small abundant species, sometimes water-worn, without any prominent character, except the fold at the base, which is more conspicuous, considering the size of the shell, than is usual in the genus.

LITTORINA, *Ferr.*

47. L. PEDROANA, Con., Pl. VI, fig. 50.—Suboval; spire very short; body whorl abruptly rounded above; aperture obliquely subovate.

Locality.—Occurs with the preceding. Recent formation.

STRAMONITA, *Shum.* PURPURA, *Lam.*

48. S. PETROSA, Con., Pl. VI, fig. 47 and 47*a*.—Subglobose; whorls four, subangulated; body whorl with three revolving rows of distant tubercles, and flattened at the summit. Spire conical; penultimate whorl with one series of tubercles.

Locality.—Tulare Valley. [Found with *Meretrix Tularana*, Con., pl. III, fig. 22 and 22*a*. Both specimens are clay casts, but very perfect.—*W. P. B.*]

III. TERTIARY SHELLS OF THE ISTHMUS OF DARIEN.

MIOCENE?

Mr. Blake has forwarded me casts of three bivalves. They are forms which are new to me, and probably Miocene species. The *Gratelupia*, except in being truncated posteriorly, much resembles *G. Hydeana*, Conrad, an Eocene fossil.

GRATELUPIA? *Desmoulins.*

49. G.? MACTROPSIS, Con , Pl. VI. fig. 54.—Triangular, inequilateral; dorsal margins equally oblique, straight; basal margin rounded anteriorly, lightly curved, posteriorly, posterior extremity truncated, direct, considerably above the line of the base.

Locality.—Isthmus of Darien.

MERETRIX.

50. M. DARIENA, Con., Pl. VI, fig. 55.—Obtusely and obliquely subovate; ventricose; inequilateral; anterior extremity angulated, and situated much nearer the beak than the base; anterior dorsal line straight and oblique; beak not prominent; basal and posterior margins profoundly rounded.

Locality.—Occurs with the preceding.

TELLINA, *Lin.*

51. T. DARIENA, Con., Pl. VI, fig. 53.—Subtriangular, compressed; anterior hinge-margin rectilinear, very oblique, extremity truncated, direct; posterior extremity regularly rounded; base moderately curved.

Locality.—Occurs with the preceding.

IV. MIOCENE FOSSILS FROM OCOYA CREEK.

The following are descriptions of some of the fossils from Ocoya creek, (Posé creek,) which occur only as casts. The collection contains many of these casts, but the descriptions are principally based upon the drawings made at the locality by Mr. Blake.

NATICA.

52. N. OCOYANA, Con., Pl. VII, fig. 57 and 57*a*.—Spire conical, volutions three or four, rounded on the sides, depressed above; body whorl very wide, depressed.

Locality.—Ocoya creek.

52. N. GENICULATA, Con., Pl. VII, fig. 67.—Globose, volutions angulated above; spire short, conical; body whorl contracted near the summit.

Locality.—Ocoya creek.

Resembles *N. alveata*, Con., of the California Eocene.

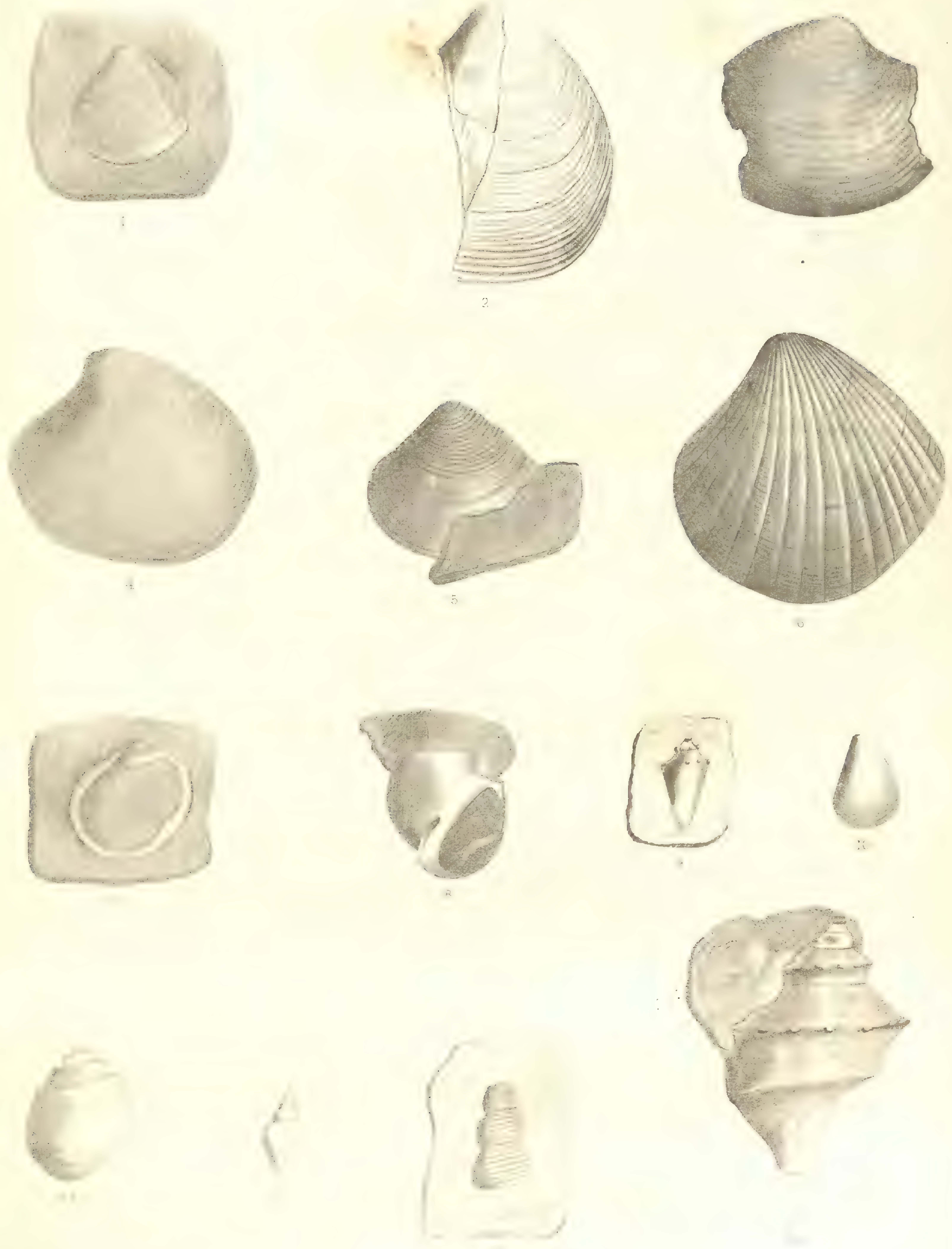
BULLA.

54. B. JUGULARIS, Conrad, Pl. VII, fig. 62, 62*a*, 62*b*.—Oblong elongated, much contracted toward the apex; acutely rounded at the base.

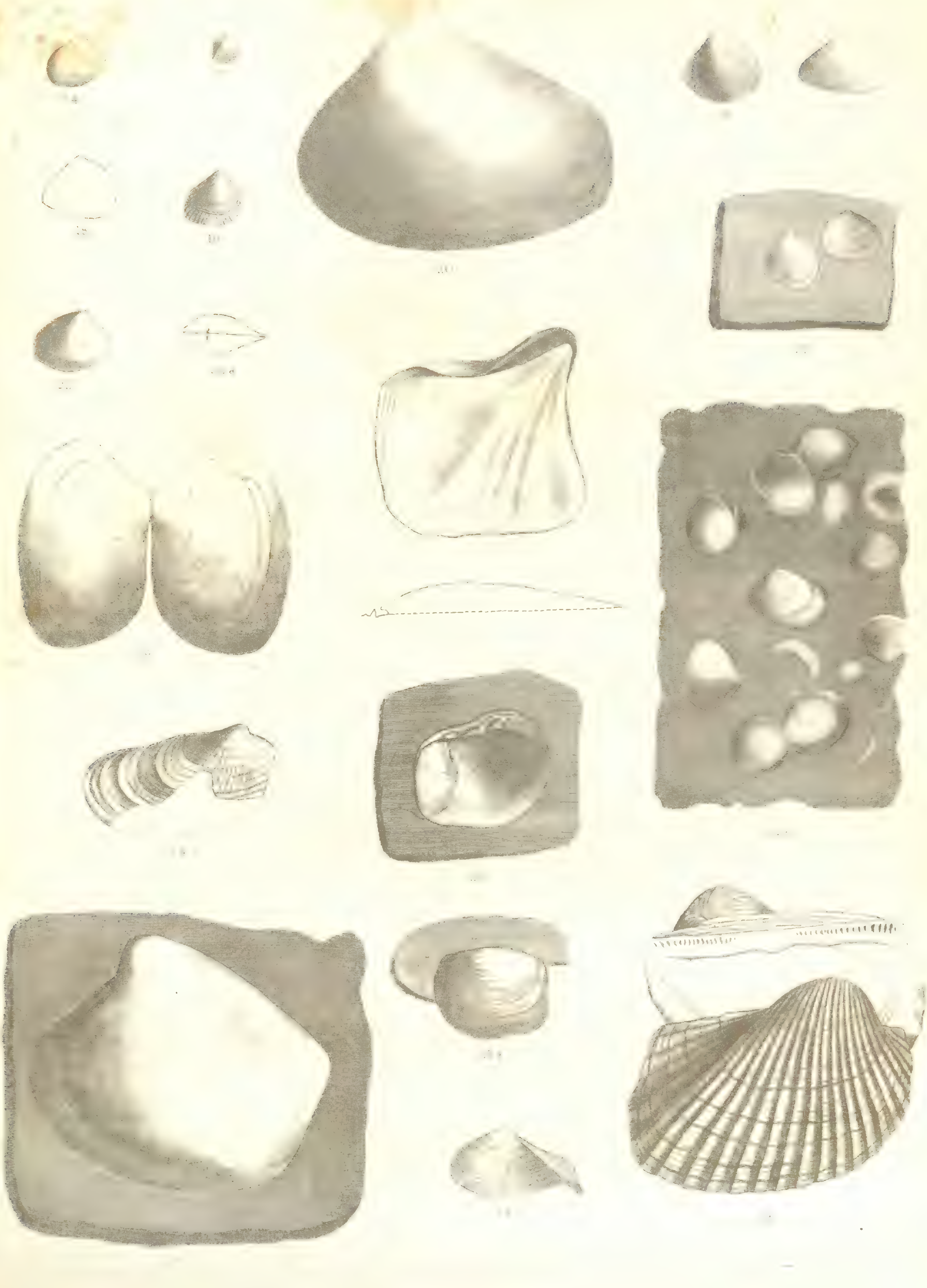
Locality.—Ocoya creek.

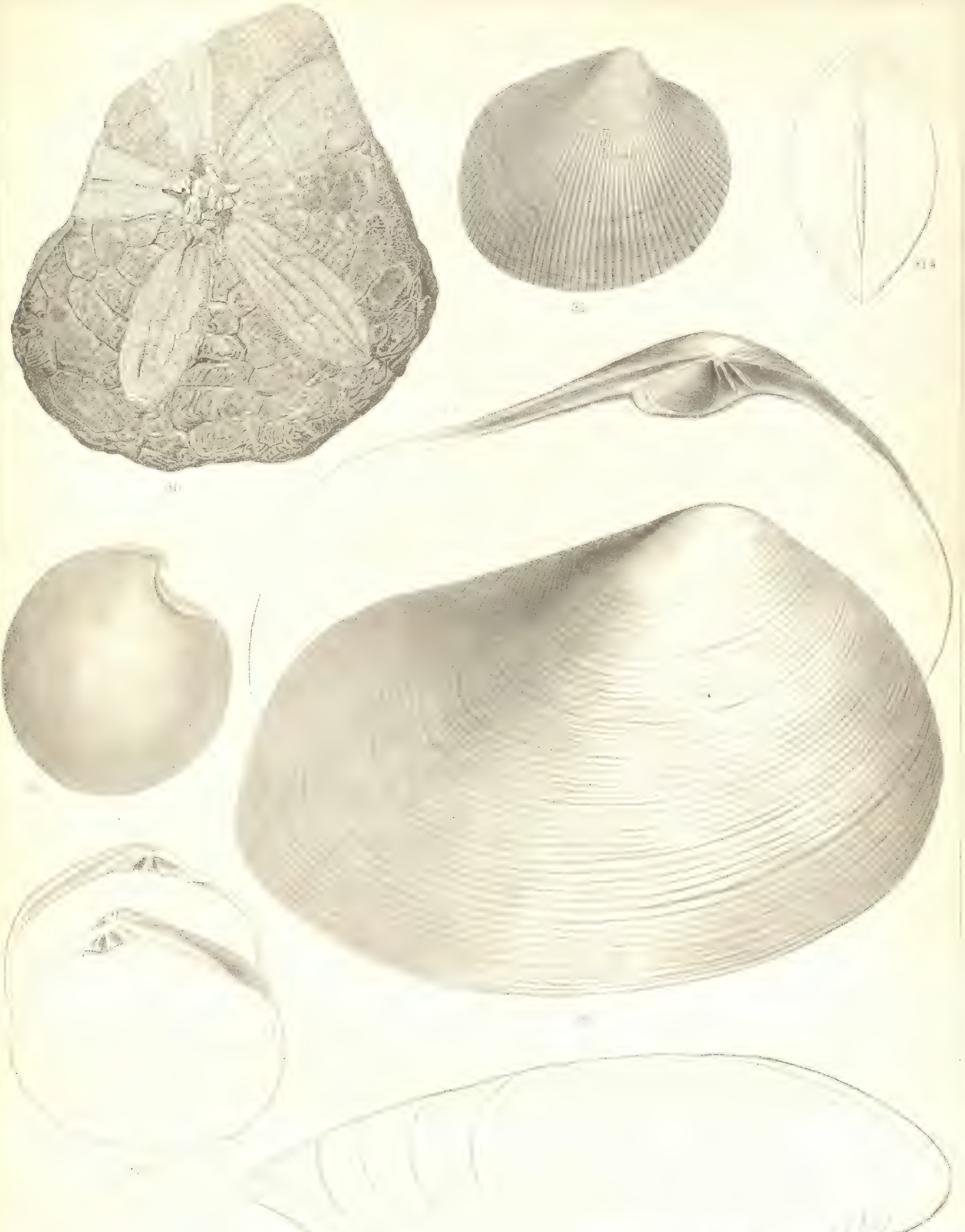
PLEUROTOMA.

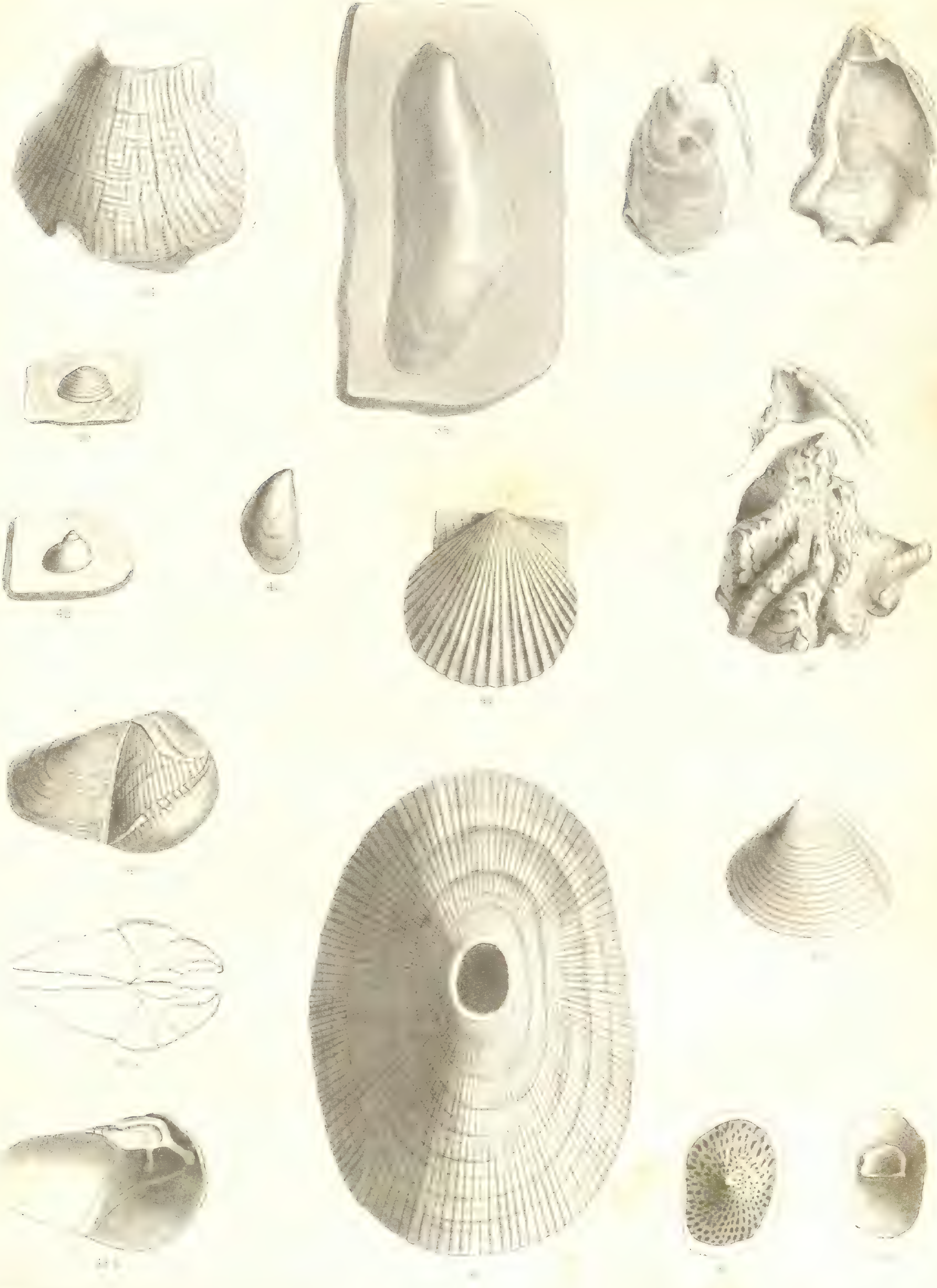
55. P. TRANSMONTANA, Conrad, Pl. VI, fig. 69.—Fusiform, with rugose revolving lines and

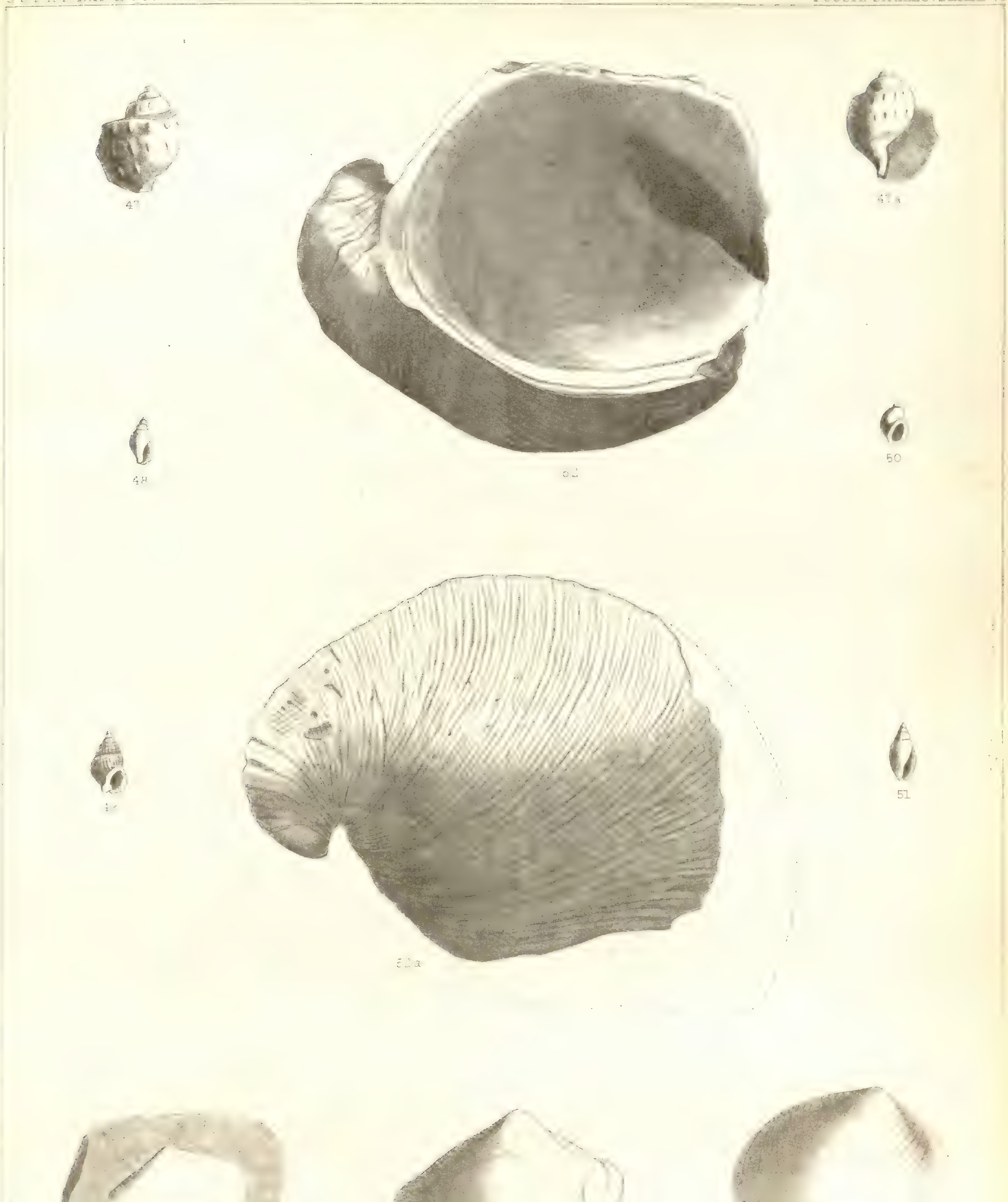


T. A. Conrad, del.








47
47a
48
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54

distant short longitudinal undulations on the body whorl; volutions of the spire rounded; longitudinally undulated.

Locality.—Ocoya creek.

SYCTOPUS.

57. S. OCOYANUS, Conrad, Pl. VII, fig. 72 and 72*a*.—Spire depressed; whorls flattened above; shoulder sub-angulated, sides somewhat flattened, columella profoundly rounded above and concave below.

Locality.—Ocoya creek.

TURRITELLA.

58. T. OCOYANA, Conrad, Pl. VIII, figs. 73, 73*a*, 73*b*.—Volutions 13 or 14, straight at the sides; rounded at base, and having well marked revolving lines, base broad; volutions suddenly tapering to the apex.

Locality.—Ocoya creek.

COLUS.

59. C. ARCTATUS, Conrad, Pl. VIII, fig. 76.—Narrow, fusiform, whorls rounded; beak very slender, somewhat sinuous.

Locality.—Ocoya creek, Cal.

TELLINA.

60, T. OCOYANA, Conrad, Pl. VIII, fig. 75 and 75*a*.—Elliptical, compressed, inequilateral; posterior extremity acutely rounded, much above the line of the base; anterior end somewhat acutely rounded; cardinal teeth robust.

PECTEN.

61. P. NEVADANUS, Conrad, Pl. VIII, fig 77.—Ovate, flat or slightly concave; ribs 17? large, flattened on the back; interstices strongly wrinkled transversely.

This shell is so much nearly allied to *N. Humphreysii* of Maryland, that, taken in connexion with *P. catilliformis*, Pl. IX, it may be regarded as a Miocene species. The strata in which they occur may safely be referred to that period.

Locality.—Ocoya creek.

62. P. CATILLIFORMIS, Conrad, Pl. IX, fig. 83.—Orbicular, plano-convex, with radiating striæ and distinct rounded ribs; ears equal.

Locality.—Ocoya creek.

This large Pecten has such a general resemblance to *P. Madisonius*, Say, of the Virginia Miocene, that I have no doubt it existed at the same period, or at least after the Eocene. There is none such now living on the coast of California, and none in the Eocene, of this group of large Pectens, which occur almost everywhere in the Miocene deposits of the Atlantic slope.

In addition to the above described species, there are many specimens and drawings in which the specific characters are not preserved with sufficient distinctness for description. Among these are individuals of the genera Arca, Solen, Dosinia and Venus.

ARTICLE III.

CATALOGUE OF THE RECENT SHELLS, WITH DESCRIPTIONS OF THE NEW SPECIES.

BY AUGUSTUS A. GOULD, M. D.

The collection consists of fresh water shells from the Colorado desert, and other localities, and of land and marine shells from the coast between San Francisco and San Diego. The new species are indicated by an asterisk.(*).

o.	Name.	Locality.
1	Ostrea	San Diego
2	Pecten monotimeris, Conrad	do
3	Pecten ventricosus, Sowerby, (also tumidus, Sow.)	do
4	Mytilus edulis, (1)	San Francisco
5	Modiola capax, Conrad	San Diego
6	Venus Nuttallii, Conrad	San Pedro
7	Venus fluctifraga, Sowerby	San Diego
8	Tapes grata, Say, T. discors., Sowerby, (straminea, Conrad)	San Pedro
9	*Tapes gracilis, Gould	do
10	Cyclas, (imperfect)	Colorado Desert
11	*Cardium cruentatum, Gould	San Diego
12	Lucina orbella, Gould	San Pedro
13	Lucina Nuttallii, Conrad	do
14	Mesodesma rubrotincta, (?) Sowerby	do
15	Tellina vicina, Adams	San Diego
16	Tellina secta, Conrad	San Pedro
17	Sphenia Californica, Conrad	San Diego
18	Petricola carditoides, Conrad, (P. cylindracea, Desh.)	Monterey—San Pedro
19	Solecurtus Californiensis, Conrad	San Diego
20	Gnathodon Lecontei, Conrad, (G. trigonum, Pettit)	Colorado Desert
21	Lottia scabra, Gould	San Francisco
22	Lottia patina, Eschscholtz	San Pedro
23	Scurria pallida, Gray, (Lott. mitra, Brod.)	do
24	Calyptrea hispida, Brod	San Pedro — San Diego
25	Crepidula incurva, Brod.	San Pedro
26	Bulla nebulosa, Gould	San Diego
27	Bulla (Haminea) virescens, Sowerby	do
28	*Bulla (Haminea) vesicula, Gould	do
29	*Bulla (Tornatina) inculta, Gould	do
30	Trochus mœstus, Jonas	do
31	*Phasianella compta, Gould	do

CATALOGUE—Continued.

No.	Name.	Locality.
32	Littorina, (undetermined)	San Diego
33	Melampus, (undetermined)	do
34	Oliva biplicata, Sowerby	San Pedro
35	*Potamis pullatus, Gould	San Diego
36	*Amnicola protea, Gould	Colorado Desert
37	*Amnicola longinqua, Gould	do
38	*Planorbis ammon, Gould	Colorado Desert — Ocoya Creek
39	*Physa humerosa, Gould	Colorado Desert
40	Succinea, (undetermined)	Ocoya Creek
41	Helix Vancouverensis, Lea	San Francisco
42	Helix San Diegoensis, Lea	Point Reyes
43	Helix infumata, Gould	do
44	Helix Oregonensis, Lea	Cypress Point

I.—FRESH-WATER SHELLS FROM THE COLORADO DESERT.

PHYSA HUMEROSA, *Gould.*

[Proceed. Bost. Soc. Nat. Hist., V. 128. Feb. 1855.]

T. solidula, subrhomboidea, polita; spira acuta, anfractibus quinque tabulatis; apertura ½ ad ⅔ long; idtudinis testæ adequans, posticè obtusa; labro expanso, columellâ vix plicatâ.—Pl. XI, figures 1, 2, 3, 4, and 5.

Shell rather large and solid, subrhomboidal, polished; all the specimens seen, (quite numerous, and apparently not weathered,) porcelain white. Whorls five, each with a broad, square shoulder, and forming an elevated, acute spire; aperture usually about two-thirds the length of the shell, sometimes but little over one-half; posterior angle obtusely rounded; outer lip slightly flaring, when viewed in profile it is slightly advanced posteriorly so as to form a recess at the junction; pillar without any conspicuous fold, thickly covered with enamel, broadly rounded and expanded at the base. Umbilical region nearly perforate.

Length of an ordinary specimen, half an inch; breadth, three-eighths of an inch; length of a variety, seven-tenths of an inch.

Found in the Colorado Desert, by W. P. Blake; also at Pecos River, by Dr. T. H. Webb.

The broadly tabulated whorls, with the acute, elevated spire and foldless pillar, clearly distinguish this species. *P. tabulata*, Gould, from New Zealand, is similar, as well as some varieties of *P. ancillaria*, Say, as figured by Haldeman, especially his figure 7, which he designates as a monstrosity; but the spire is more elevated, and the deep suture always renders the whorls distinct, and the absence of a columellar fold is a still further distinctive mark. It would be difficult to distinguish the young by themselves from several other species, though they begin to show the angularity of the whorls quite early.

PLANORBIS AMMON, *Gould.*

[Proceed. Bost. Soc. Nat. Hist., V. 129. Mar. 1855.]

T. magna, discoidea, subconica, subtiliter striata; latere sinistro late et profundè concavo,

anfractus quatuor obtusè angulatos exhibente; latere dextro excavato, anfractus duos cum dimidio cstendente; apertura ovato-triangularis, interdum utroque valdè expansa.—Pl. XI, figures 12, 13, 14, 15, 16, 17, and 18.

Shell discoidal, attaining a large size, delicately striated, of a watery-white color; when laid upon the right side the shell has a remarkable conical or dome-shaped aspect, the extreme periphery being in a plane with the right side or base, from which the whorl grapually slopes upwards, terminating at the summit in a broad and deep concavity, exhibiting four well-marked, obtusely angulated whorls; the right side is decidedly concave, exhibiting two and a half or three well-rounded volutions. Aperture ovate-triangular, in middle-sized specimens projecting about equally to either side, in small specimens projecting to the right side only, and in the largest, spreading amply to both sides, and especially the right, where it expands and forms a remarkable ear-shaped aperture.

Diameter of the disk, in the middle-sized specimens, five-eighths of an inch, and in the largest, one inch; axial diameter of the first, one fourth of an inch, of the latter, half an inch; and in one specimen the breadth of the aperture, from side to side, is five-eighths of an inch.

Locality.—Found in the Colorado Desert; and also by Dr. Webb.

I have associated specimens differing greatly in size and in developement of the aperture, but all agreeing in the peculiar slope of the outer volution, giving a conical outline when lying on the side. The fully developed specimens have the general aspect of *P. corpulentus*, Say; but besides the form of the volution and the consequent shape of the aperture, that shell is more coarsely striated, the whorls on the right side lie nearly in the same place, and on the left side but two whorls appear. It differs from *P. trivolvis*, Say, in nearly the same particulars. In external surface it is more like *P. glabratus*, Say.

AMNICOLA PROTEA, *Gould.*

[Proceed. Bost. Soc. Nat. Hist., V. 129. Mar. 1855.]

T. parva, elongata, gracilis, variabilis; anfractibus 7–8 convexis, profundè discretis, simplicibus, vel filis volventibus et costis longitudinalibus variè ornatis et clathratis: apertura ovata; labro continuo, simplici, anfractum penultimum vix attigente. Pl. XI, figures, 6, 7, 8, and 9.

Shell small, turreted, slender, greatly elongated, chalky-white, (so far as seen,) variously proportioned, composed of seven or eight whorls, which are either convexly rounded or broadly shouldered, and separated by a deep suture—the surface either smooth throughout, or more frequently sculptured with revolving threads or longitudinal ribs or decussated by both in various proportions, the upper whorls being in nearly every instance decussated; aperture ovate, lip simple, continuous, generally detached from, or scarcely appressed to the penultimate whorl, in many instances leaving an umbilical chink.

Largest specimens three-tenths of an inch long and half an inch broad.

Found in the Colorado Desert; also by Dr. T. H. Webb.

This species is peculiar on account of its elongated, slender form, and differs from the other species of the genus yet described in being variously sculptured with revolving ridges and longitudinal folds, like many of the Melaniæ. It varies greatly also in its relative proportions of length and breadth. It is as slender as *A. attenuata*, Haldeman, and much larger. [This appears to be the same shell as that subsequently described by Mr. Conrad, under the name of *Melania exigua.*]

AMNICOLA LONGINQUA, *Gould.*

[Proceed. Bost. Soc. Nat. Hist., V. 130. Mar. 1855.]

T. parva, elongato-ovata, lævis, apice obtuso, spiræ anfractibus quinque rotundatis, suturâ profundâ discretis: apertura elliptica, postice rotundata; columellâ profundè arcuatâ.—Pl. XI, figures 10, and 11.

Shell small, elongate ovate, horn-colored, (or blanched chalky-white,) surface quite smooth; apex obtuse, whorls five, well-rounded and separated by a deep suture. Aperture elliptical, broadly rounded posteriorly; lip simple, copiously incrusting the pillar margin, which is profoundly arcuate; umbilical region nearly perforate.

Length one-eighth of an inch, breadth one-tenth of an inch.

Found in the Colorado Desert.

In form it is much like *A. Cincinnatiensis*, Haldeman, or like his *A. galbana*.

II. MARINE SHELLS FROM THE COAST.

POTAMIS PULLATUS, *Gould.*

[Appendix to Prelim. Geol. Report of W. P. Blake, 1855.]

Testa turrita, gracilis, solida, rudis, fusco-cinerea; anfractibus ad decem convexiusculis, plicis circiter decem convexiusculis arcuatis compressis instructis, et filis ad quinque volventibus cinctis; tribus ultimis varice munitis: apertura parva, subcircularis, nitidè rufo-nigra; basi vix effuso et contorto; labro expanso. Pl. XI, figures 23, 24.

Shell elongated, turreted, slender, solid, rough, and dusky, composed of ten closely revolving moderately convex whorls, ornamented with about 16 longitudinal, curved, compressed folds, and about five revolving threads, which usually form beads where they crown the folds; the three anterior whorls are fortified with a strong varix, about two-thirds of a volution distant from each other. Aperture small, nearly circular, slightly produced and contorted at base, very dark and glossy liver-brown within; everted.

Length 1¼ inch, breadth two-fifths of an inch.

Locality.—Brought from San Diego by Dr. Tho. H. Webb and Wm. P. Blake.

This shell is apparently very common, and yet I find no description answering to it. From *P. sacratum*, Gould, it may be distinguished by its small and dark-colored aperture, and the longitudinal folds. It is much like *P. iostoma*, Pfeiffer, a Cuban species. Some of the specimens are very much more slender than others.

PHASIANELLA COMPTA, *Gould.*

[Preliminary Report, 1855.]

Testa parva, solida, ovato-conica, imperforata, polita, cinerascens, lineis olivaceis tenuissimis obliquè volventibus ornata: spira acuta; anfractibus quatuor rotundatis; ultimo ad peripheriam obtusè angulato et interdum tessellatim fasciato: apertura circularis; labro tenui, albo; columellâ albâ, compressà; faucibus callo albo incrassatis. Pl. XI, figs. 25, 26.

Shell small, solid, ovate, imperforate, smooth and shining, ashy white, minutely and closely lineated in an obliquely spiral manner with olive green. Whorls four, well rounded, forming an acute spire, the outer one obtusely angular at periphery, where there is sometimes a delicate range of catenated white and olive spots; aperture nearly circular; lip very thin, showing the

lineations on the inner margin; throat coated with bluish white enamel; pillar flattened; white. Operculum patelliform, ivory-like, the outer convex surface marbled black and white; the inner surface black.

Length one-fourth of an inch; diameter one-fifth of an inch.

Locality.—Found at San Diego by Mr. Blake, and also by Dr. Webb.

This pretty little shell is usually more or less coated with cretaceous matters, but when cleaned exhibits a beautifully lineated surface, peculiar on account of the lines running so nearly in the ordinary direction of revolving striæ. The coloration, however, sometimes consists of olive and white tessellations and blotches. It would accord pretty well with *P. perforata*, Philippi, did it not lack the distinguishing mark of that species, its perforation.

BULLA (TORNATINA) INCULTA, *Gould.*

[Preliminary Report, 1855.]

Testa minuta, solidula, eburnea, elongato-ovalis, longitudinaliter minutissimè striata: spira elevata; anfractibus quatuor tabulatis: apertura linearis, octantes septem longitudinis testæ adequans, anticè dilatata, posticè rotundata; labro incurvato; columellâ satis arcuatâ, callosa, uniplicatâ. Pl. XI, figures 27, 28.

Shell minute, solid, ivory white, elongated-oval, minutely striated longitudinally; spire elevated, consisting of about four tabulated whorls. Aperture about seven-eighths the length of the shell, not attaining the end of the outer whorl, linear, constricted at the middle and somewhat dilated anteriorly, posterior angle rounded; pillar moderately arcuate, usually presenting a well-marked fold at the anterior fourth, and well coated with enamel.

Length one-eighth; breadth one-twelfth of an inch.

Locality.—San Diego.

May be best compared with *B. fusiformis*, A. Adams, and is also very closely allied to *B. obstricta*. Gould. The spire varies much in elevation, sometimes, indeed, being on a level with the outer whorl. The form of the whole shell is also more or less cylindrical.

BULLA (HAMINEA) VESICULA, *Gould.*

[Preliminary Report, 1855.]

Testa parva, fragilis, ovato-globosa, pallidè citrina, posticè truncata: apertura spiram superans, longitudine duplo adequans, anticè et posticè benè rotundata; columellâ profundè arcuatâ, vix callosâ. Pl. XI, fig. 29.

Shell small, fragile, ovate globose, pale greenish yellow; body of the shell small, truncate at summit; outer whorl large; aperture about twice the length of the body of the shell, and projecting above it, broadly rounded both posteriorly and anteriorly; outer lip inflexed at the middle; pillar profoundly arcuate, with a narrow delicate callus.

Length three-tenths; breadth one-fifth of an inch.

Locality.—Brought from San Diego by Mr. Blake.

It has about the size and general appearance of *B. rotunda*, A. Adams, but has not so large a body, and is more open anteriorly; in this latter respect it is more like *B. Natalensis*, a much larger shell.

CARDIUM CRUENTATUM, *Gould.*

[Preliminary Report, 1855.]

Testa parva, tenuis, transversim rotundato-ovata, ventricosa, inequilateralis, polita, straminea,

ad aream dorsalem posticam rufo tincta, lineis radiantibus crebris vix insculpta; umbonibus eminentibus; extremitatibus rotundatis, rufo biradiatis; intus citrina sanguineo conspersa; margine argutè crenulato. Plate XI, figures 21, 22.

Shell small, thin, inequilateral, rounded ovate, moderately ventricose, surface smooth and shining, with very delicate lines of growth, and numerous, indistinct, radiating striæ, more distinct posteriorly and near the margin; anterior end broadly rounded; posterior end narrowed, semi-rhomboidal, the dorsal margin rather rapidly declining; color pale lemon, or straw-color, somewhat discolored or blotched with rufous, the beaks biradiate with brown, and the posterior dorsal area brownish; interior bright lemon-color, beautifully stained with dark liver-brown, especially near the beaks and posteriorly; inner margin minutely crenulated. Height and length five-eighths of an inch; breadth three-eighths of an inch.

Locality.—Inhabits San Pedro.—*Wm. P. Blake.*

Compared with *C. Elenense,* Sowb., it is much less elevated and differently colored, though the general characters are very closely allied. It is more like *C. Mortoni*, Con., but is less solid, inequilateral, less truncate posteriorly and more freely colored within, and the internal margin in that shell is not crenulated.

TAPES GRACILIS, *Gould.*

[Preliminary Report, &c., 1855.]

Testa parva, tenuis, inequilateralis, elongato-ovata, albida, obsoletè fusco radiata, ad aream dorsalem posticam fuscata, concentricè striolata; extremitatibus rotundatis, extr. antico acutiore; intus candida.—Pl. XI, figures 19, 20.

Shell small, thin, transversely elongate-ovate, rather compressed, beaks, at the anterior third, whitish, with traces of dusky radiations on the disks, and clouded with dusky on the dorsal areas; surface with very fine concentric lines of growth, coarser at the ends; extremities rounded, the posterior somewhat obliquely, the anterior narrower and somewhat more acute; anterior dorsal area depressed, without any line of demarcation; interior white.

Length three-fourths of an inch; height half an inch; breadth an eighth.

Locality.—Brought from San Pedro by Mr. Blake.

Belongs to the group with *T. florida* and *geographica*, but is less inequilateral and less angular than those shells. It may grow much larger than the present specimen, and is pretty certain to vary in coloring.

In addition to the preceding are two or three species left undetermined in consequence of imperfect specimens, or because the characters are not sufficiently marked to render their novelty decisive. The following remarks may be added in regard to some of these:

(1.) MYTILUS EDULIS, or very closely allied. It seems to differ in having the dorsal angle at a greater distance from the beak—the posterior dorsal slope more rapidly declining and more curved, as in M. *hamatus*—the interior more pearly, and the margin more uniformly deep black.

Locality.—San Francisco.

(2.) OSTREA.—A small parasitic *Oyster*, on twigs, probably of Gorgonia, usually projecting equally to either side. The form is elliptical, the under valve having a groove for the twig, with a corresponding eminence in the upper valve; sometimes it adheres by but one edge, and then assumes an oblique, alate form, like Avicula. It is quite thin, lineated, radiately ornamented with fasicles of brown lines.

Locality.—San Diego.

Another oyster from San Diego, about two inches long, narrow and moderately widening, slightly sigmoid in form, its margins simple and the extremity somewhat truncate and undulate or dentate, with four or five radiating grooves; shell compact, upper valve purplish. It occurs in clusters intimately grouped, much like the parasitic oysters of Carolina, but more elongate, less digitate at the end, less cavernous under the beak, and less black within.

Locality.—San Diego.

ARTICLE IV.

LETTER FROM PROFESSOR J. W. BAILEY, DESCRIBING THE STRUCTURE OF THE FOSSIL PLANT FROM POSUNCULA RIVER.

WEST POINT, NEW YORK, *March* 22, 1855.

DEAR SIR : I send herewith a sketch of the structure of the fossil plant from the boulder in the bed of Kern River, west slope of the Sierra Nevada.

The plants, as far as I can make out the structure, are annual shoots of an exogenous structure, presenting a distinct pith, (p. in the drawings, Plate XII, figs. 1 and 2); medullary rays (r); a layer of liber (1); and a loose succulent bark (b), having large lacunæ (la). In the outer portion of the wood a series of large vessels, v 1; of smaller, v 2; and of still smaller ones, v 3, are placed. I could not detect upon these vessels any indications of spiral or dot.

The specimens from the east slope of the Sierra agree in all essential points with the above, the only difference noticed being the development of a few large vessels surrounded with woody fibre within the pithy portion.

I cannot venture, with the limited data furnished above, to form any opinion upon the affinities of these plants.

The vertical section, fig. 1, is made up from observations of various splinters from different parts of the plants which I encased in Canada balsam. The horizontal section, fig. 2, is from the section made by the lapidary in New York, which I afterwards rubbed down to half the thickness the lapidary had given. The section thus obtained was as perfect as if from a recent plant. It showed the shells filled with transparent silica, and in the larger lacunæ the arrangement of the silica into small sperical agates was distinctly visible.

Yours, very respectfully,

J. W. BAILEY.

W. P. BLAKE, Esq., *Washington, D. C.*

ARTICLE V.

DESCRIPTION OF THE STRUCTURE OF THE FOSSIL WOOD FROM THE COLORADO DESERT.

By PROF. GEO. C. SCHAEFFER.

There are two distinct specimens of this wood, one marked "Pilot Knob;" they are, however, identical in structure when examined under the microscope.

A slight examination, under a low power, gives a very different idea of the character of these woods from that obtained by closer examination with high powers, comparing different parts of the same specimen.

The peculiarity consists in the winding or contorted medullary rays which at times close upon each other, and again open, to form a wide space. This, however, is an accident, as will presently be shown, and not directly dependent upon the normal structure.

Transverse section.—This view shows indistinct annual rings of considerable thickness, $5\frac{1}{2}$ being found in five-tenths of an inch. Beside these annual rings, there are found, in some cases, subordinate rings, showing a partial interruption of growth during one season. The medullary rays are very much bent, being sometimes folded closely upon themselves. They are formed of three rows of cells in breadth, but these cells are not in the same horizontal plane; they are narrow and short, (radially)

The ducts are large, of one kind, generally single, and when double, but seldom compressed so that their adhering sides become flat, as is the case in many woods. The cavity of the ducts is filled with dark-brown matter, while the thick walls are lighter in color. Except at or near the lines dividing the annual rings, the ducts are not arranged in continuously circular lines, but are interrupted in their order.

The wood cells are rarely to be seen except around the ducts, and where the structure is least altered they are found arranged in regular rows in both directions; in some cases with thick walls and narrow cavities, in others in thin walls and larger cavities. Where these cells are least altered they are also brown in color; the more they are changed the lighter they become; and generally at a distance from the ducts they entirely disappear. The space between the medullary rays is then filled with a transparent siliceous paste, which in some places seems to show waving lines marking out the boundaries of successive deposits. It will now be easy to explain the cause of the folds in the medullary rays. The tree, before silification, had partially decayed, the cells of the rays, the ducts, and the surrounding wood resisted, or rather did not decay at all, and when pressure was made upon the whole mass the decayed portions gave way, and the rays bent, but as they did not quite touch each other, owing to the interposed ducts and unaltered wood, cavities were left in which the amorphous paste was deposited.

The uniformity of this action, and the curious appearance caused by it, at first seems to indicate an original difference in the durability of the different parts, but this is not probable. The

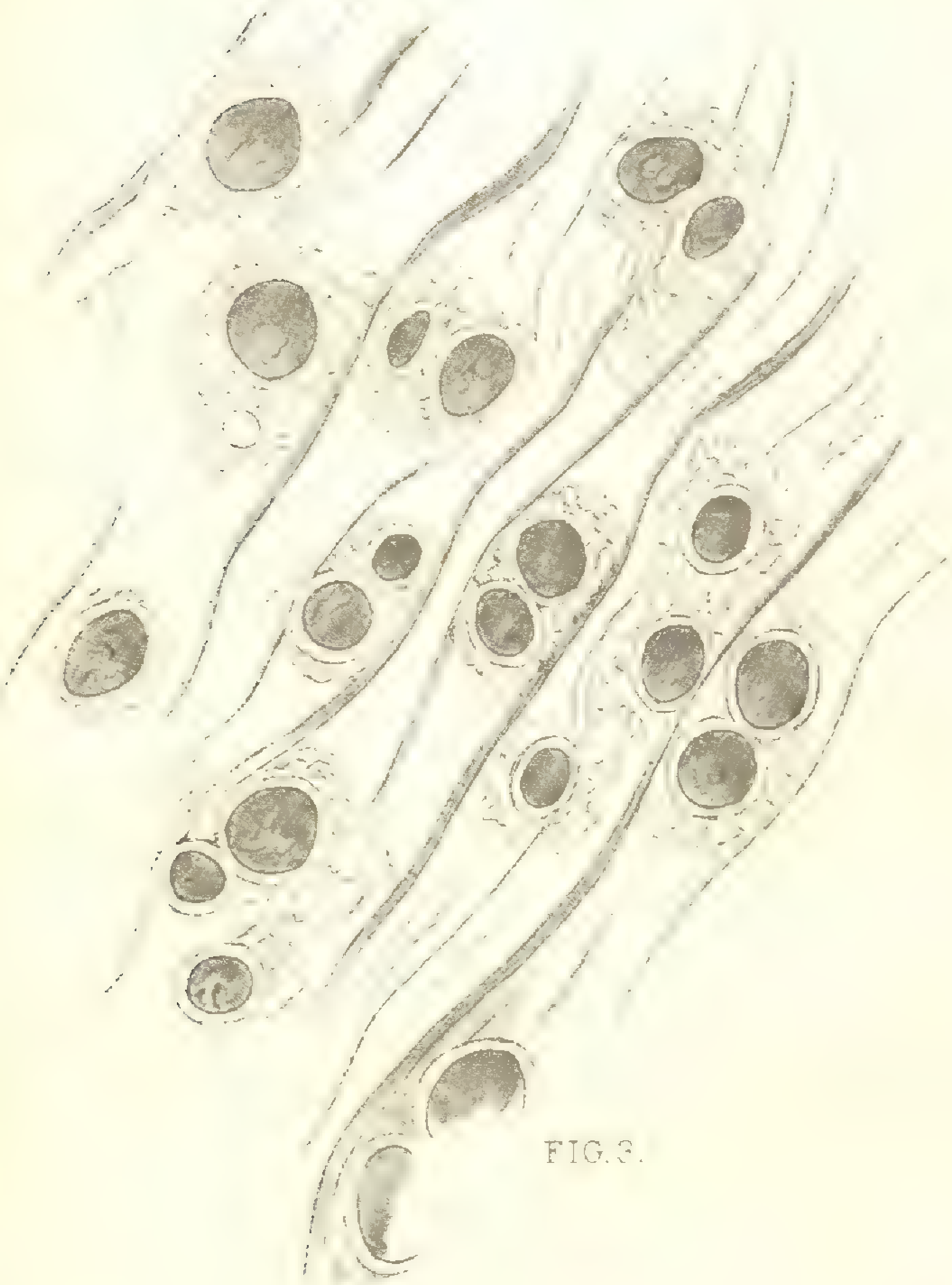


FIG. 3.

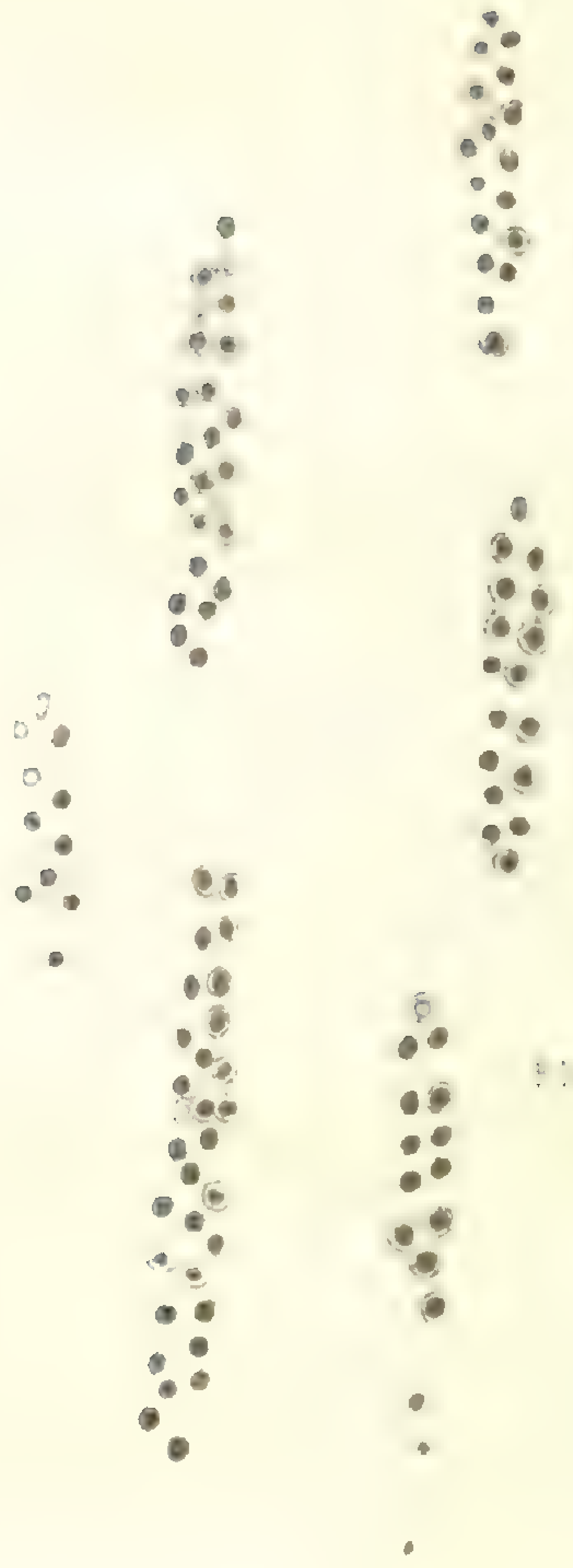
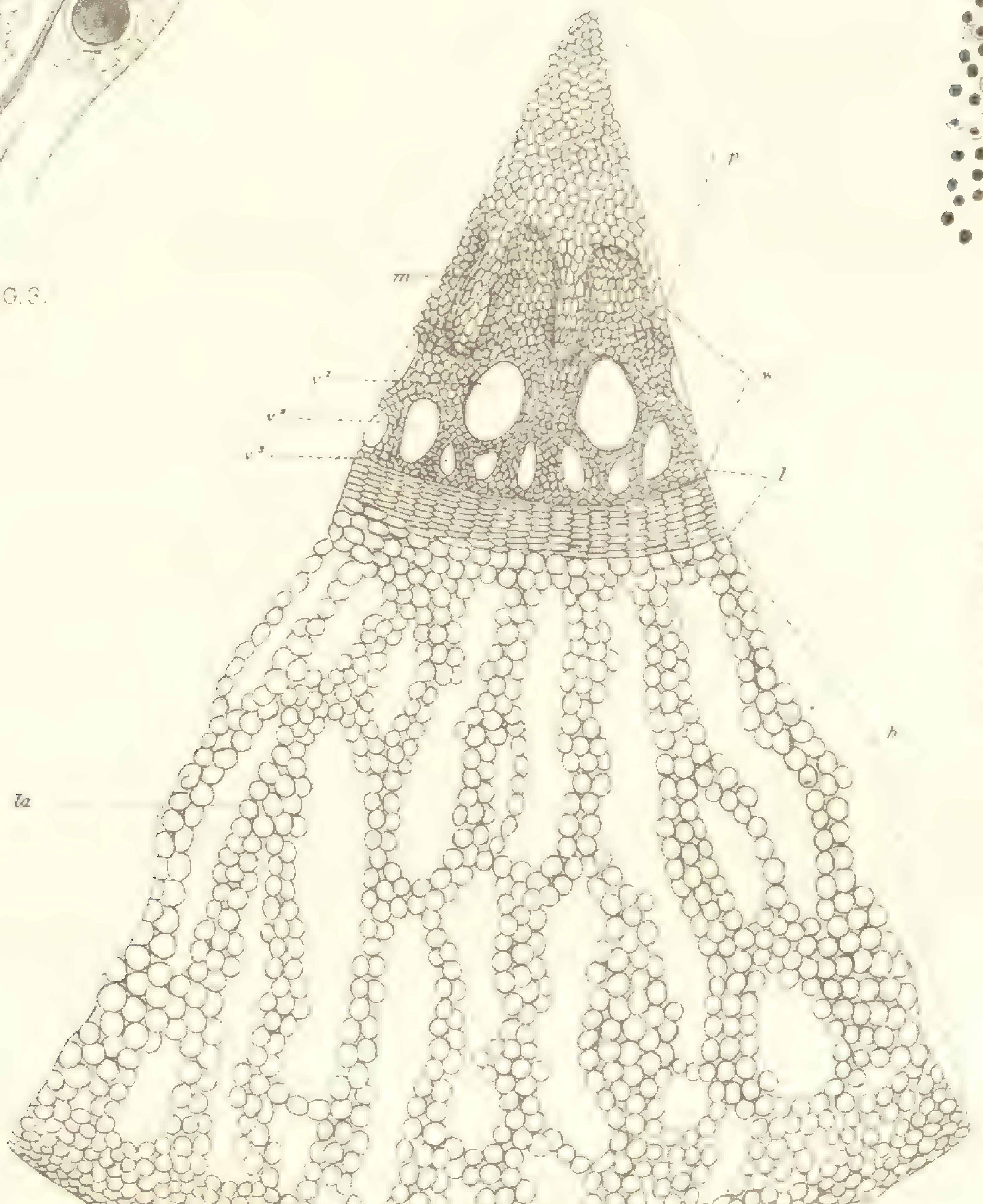


FIG. 4.



EXPLANATION

p pith
w. wood
l liber
b. bark
m medullary ray
v^1 large vessels
v^2 intermediate
v^3 smallest
la lacunae

Scale of inches

FIG. 2.

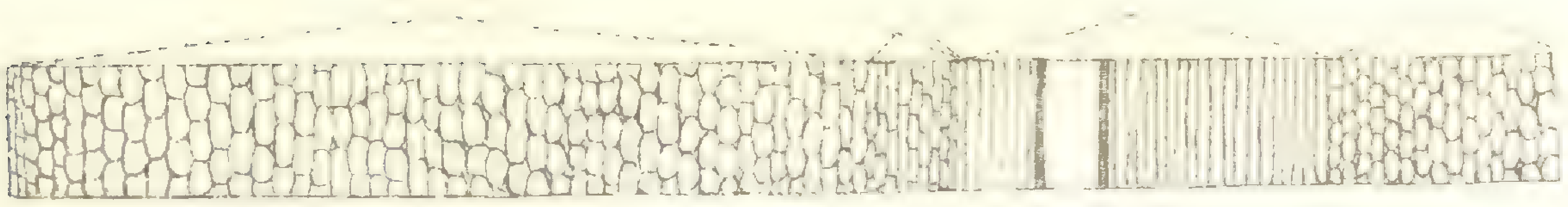


FIG. 1.

SILICIFIED WOOD

most likely view is, that some preservative matter from without found its way readily through the ducts, and spread into the surrounding wood, and quite through the cells of the medullary rays. The brown color deepest in the cavity of the ducts, and fading gradually at a little distance from them, confirms this view.

Radial section —In this view the medullary rays are seen composed of uniform cells of small size, closely covering the walls of the ducts where structure cannot be made out. Very few wood cells can be distinctly seen.

The tangential section shows an end view of the rays, composed of fifteen to twenty and sometimes twenty-five cells, lengthwise, and three in width, as before stated, not in the same horizontal plane. In this view the small size and closeness of the cells bent round the ducts give at the first glance the appearance of annular or spiral vessels, but a closer examination reveals the true structure. The wood is, therefore, that of an exogen, and is not coniferous, and must be comparatively modern.

It is to be regretted that the structure of the ducts could not be clearly made out, but from the description it can be easily ascertained what it should be.

The presence of wood parenchyma could not be determined. These characters will easily enable us to determine this wood in specimens less altered, from which the relations to existing wood can be better determined. There is a close resemblance to a fossil wood from Antigua, figured in Witham; this last, however, is unaltered.

EXPLANATION OF THE FIGURES.

Plate XII, Fig. 3.—Transverse section of fossil wood from the Colorado Desert; magnified 100 times.

Fig. 4.—Tangential section; more highly magnified. The cells of the medullary rays seem to be slightly separated; but this results from the view being somewhat oblique; the direction of the rays altering so much that it is difficult to obtain a section strictly perpendicular to more than one series.

ARTICLE VI.

CHEMICAL EXAMINATIONS OF SOILS AND INCRUSTATIONS.

BY J. D. EASTER, PH. D.

WASHINGTON, *November* 14, 1855.

SIR: Enclosed I have the pleasure of transmitting to you the results of my examination of the specimens of rocks, soils, salts, &c., placed in my hands by you for analysis. I have limited myself, in regard to the character of the examination, chiefly by the schedule furnished me and your written instructions. The numbers are those attached to the labels, and are cited in the order of examination.

I remain, very respectfully, yours,

JOHN D. EASTER,

WM. P. BLAKE,

Geologist U. S. Pacific Railroad Survey.

No. —. Limestone from the Tejon Pass.

Contains a considerable quantity of silica.

Carbonate of lime.
Alumina.
Oxide of iron.
Magnesia, (little.)
Phorphoric acid, (trace.)

No. 146.—*Rock from under Basalt, Fort Miller, San Joaquin River.*

Soluble in water ; chlorides of—

Sodium.
Calcium.
Magnesium.

Soluble in hydrochloric acid—

Alumina.
Oxide of iron
Sulphate of lime, (trace.)
Magnesia.
Soda.
Potash, (trace.)

The residue consists of sand and clay.

No. 153.—*Dark Bituminous clay.—San Pedro.*

Heated in a tube closed at one end it emits a strong bituminous odor and gives a small sublimate of sulphur. Burns in the air to a redish-brown mass.

No. 155.—*Bituminous silica.—San Pedro.*

A hard black silicious rock. Heated in a tube closed at one end gave a distillate of bitumen and water. Fused with soda on charcoal yields a hepar of sulphuret of sodium.

The finely-powdered mineral was fused with carbonic of soda and silica, separated in the ususl way. The acid solution contained—

Alumina and oxide of iron.
Oxide of manganese trace.
Lime, inconsiderable quantity.
Magnesia.
Sulphuric acid.
Phorphoric acid.

The presence of fluorine could not be detected. The presence of notable quantities of soda and potash was detected by Smith's process of fusion with carbonate of lime and sal ammoniæ. The infusorial (animal) origin of the rock is beyond a doubt.

No. 162.—*Clay from the bank at the Alamo Well, Colorado Desert.*—The aqueous extract contains—

Chloride of sodium.	Carbonic acid.
Lime, (carbonate.)	Sulphuric acid, (trace.)
Magnesia.	

The acid extract contains beside these, alumina and oxide of iron, and a trace of potash.

No. 204.—*Limonite, (Mariposa.)*—Limonite—a hydrated peroxide of iron, containing traces of silica, lime, and magnesia. No sulphur.

No. 250.—*Travertine, from Pilot Knob.*—The finely-powdered and dried mineral was dissolved in hydrochloric acid, the insoluble residue of silica separated by evaporation, and afterwards fused with carbonate of soda, by which a considerable quantity of alumina was separated from it. The acid solution filtered from the silica was accurately divided by measure into two equal parts, from one of which sulphuric acid was precipitated by chloride of barium. The other portion was treated with ammonia, and the precipitated oxides washed by decantation till only $\frac{1}{1200}$ of the original salts remained in the water. Alumina was then separated by potash, and precipitated by hydrosulphuret of ammonia. The oxide of iron was ignited together with the filter on which it was washed, re-dissolved in acid, and a minute residue of silica filtered off. The solution was neutralized by ammonia, the precipitate of oxide of iron filtered off, and the filtrate added to the first filtrate from alumina and iron. Lime was precipitated as oxalate and weighed as carbonate. The filtrate from the lime was evaporated to dryness and ignited, magnesia removed by caustic baryta, the excess of baryta by sulphuric acid, and the residue of sulphate of soda ignited and weighed. Carbonic acid was estimated by loss; chloride and magnesia were estimated in separate weighed portions. Fluorine was sought for without success. The analysis gives as the composition of the mineral—

Silica	9.10
Lime	48.08
Carbonic acid	37.63
Magnesia	0.52
Alumina	2.085
Oxide of iron	1.106
Soda	1.81
Chlorine	0.02
Sulphuric acid	0.19
Phosphoric acid	trace.
	100.541

No. 253.—*Incrustation from the Hot Springs of San Bernardino.*—Aqueous extract contains only a small quantity of chloride of sodium. In hot hydrochloric acid the mass dissolved with strong effervescence, leaving a residue of silica and alumina. The solution contains—

Lime, (carbonate,) chief constituent.	Alumina and oxide of iron, (traces.)
Silica, (soluble in acid.)	Phosphoric acid, (trace.)
Magnesia.	

A distinct reaction for fluorine was obtained by heating the powdered mineral with fragments of marble and concentrated sulphuric acid in a dry flask, passing the gas through aq. ammonia, evaporating this solution to dryness, redissolving, filtering, and testing this filtrate evaporated to dryness by etching. This specimen deserves a complete quantitative analysis, which would throw much light on the character of the water of the spring.

No. 254.—*Rock impregnated with salts, Mojave River.*—A portion digested in boiling water contained—

Chloride of sodium.	Sulph. magnesia.
Chloride of calcium,	Nitrate of soda, (a trace.)
Sulphate of lime.	

No. 256.—*Saline Efflorescence, Kern Lake.*—

Carbonate of soda.	Traces of—Sulphates lime and magnesia.
Sulphate of soda.	Chloride of sodium.

No. 256½.—*Saline Efflorescence, Casteca Lake, Cañada de las Uvas.*—Soluble in water, contains—

Sulphate of magnesia.	Carbonate of lime.
Sulphate of lime.	Chloride of sodium.

No. 258.—*Calcareous incrustation, Cascade creek, Tejon.*—Digested with hydrochloric acid, it leaves a considerable residue of sand. The solution contains—

Lime, (carbonate.)	Chloride of potassium, (a trace.)
Alumina and oxide of iron.	Sulphate of magnesia.
Chloride of sodium.	Phosphoric acid, (trace.)

No. 259.—*Incrustation, Santa Anna R., Oct.* 11*th.*

Chloride of sodium.	Carbonate of soda.
Sulphate of soda.	Sulphate of magnesia, (trace.)

No. 260.—*Saline mass—Brought by Lieut. Williamson from the mountains.*

Chloride of sodium.	Sulphate of soda.
Sulphate of lime, (little.)	Sulphate of magnesia.

No. 261.—*Incrustation on the soil, Cohuilla villages, November* 18.—Soluble in water.

Chiefly—Chloride of sodium.	Carbonate of lime.
With—Sulphate of soda.	Sulphate of magnesia.
Sulphate of lime.	

No. —.—*Incrustation from Soda Lake.*—The aqueous solution reacts strongly alkaline. Contains—

Carbonate of soda.	Chloride of sodium.
Carbonate of lime, (little.)	Sulphate of magnesia, (traces.)

The mass is easibly fusible. Residue is black and white sand.

No. 262.—*Saline crust, Colorado Desert, November* 20.—Treated with water it leaves a large insoluble residue.

The aqueous extract contains—

Chloride of sodium.
Sulphate of magnesia.
Sulphate of lime, (small)

The residue consists of—

Silica.
Alumina and oxide of iron.
Carbonate of lime.
Carbonate of magnesia.

No. 263.—*Soil of Cohuilla Valley, November* 18.—According to your instructions I determined only the sand, organic matter, lime, and saline soluble matter. The soil contains numerous small shells, which were not separated for the analysis.

Constituents soluble in water:

Alumina and oxide of iron.
Lime.
Magnesia.
Soda abundant.
Potash abundant.
Phosphoric acid.
Sulphuric acid.
Chlorine.
Organic matter.

Soluble in acid:

Silica.
Clay and oxide of iron and magnesia.
Magnesia, (unusually large.)
Phosphoric acid.
Sulphuric acid.
Soda.
Soda.

Total amount soluble in water	1.58 p. c.
Carbonate of lime	16.59
Sand	60.00
Total organic matter	1.30

No. 264.—*Saline soil, near Mojave River.*—It effervesces strongly with dilute acid. The aqueous extract contains—

Chloride of sodium.
Carbonate of soda.
Sulphate of soda.
Sulphate of magnesia, (little.)

No. 265.—*Soil from San Bernardino.*—A sandy loam, containing 70 per cent. of sand; consisting of angular grains of quartz; much yellow mica; fragments of a dark, undistinguishable rock; occasional grains of feldspar, and a notable quantity of magnetic iron. Organic matter = 3.26 p. c. Qualitative tests indicated the presence of the following substances:

Silica.
Alumina and oxides of iron and magnesia.
Lime.
Magnesia, (little.)
Soda.
Potash, (traces.)
Chlorine abundant.
Sulphuric acid.
Phosphoric acid.

The color of this soil, which seems to possess all the elements of extreme fertility, is a warm dark-brown.

No. 266.—*Sub-soil, Bernardino Valley.*—Contains 75.5 of sand, of much the same character as the foregoing, except that it contains calcareous particles, effervescing strongly with dilute acids. It contains—

Silica.
Alumina and oxide of iron.
Carbonate of lime, 1.09 p. c.
Magnesia, (very little.)
Sulphuric acid.
Phosphoric acid.
Chloride of sodium abundant.
Potash abundant.

CATALOGUE

OF THE

GEOLOGICAL COLLECTION,

WITH

DESCRIPTIONS OF SEVERAL OF THE SPECIMENS.

I. GRANITIC AND METAMORPHIC.

No.	Name.	Locality.
1	Granite, with hornblende and mica	Tejon Pass, at the summit
2	Compact granite rock, metamorphic?	Tejon Pass, near Station 15
3	White crystalline limestone	Tejon Pass, east slope
4	Metamorphic sandstone	Tejon Pass, adjoining limestone No. 3
5	Limestone with garnets	Tejon Pass, near eastern base
6	Garnets in limestone	do do
7	do	do do
8	Syenitic granite	Fort Miller
9	Granitic rock, with feldspathic veins, underlying basalt	do
10	Granite	July 23
11	Ferruginous slate, from the walls of the bed of iron ore	Near Burns' creek, Mariposa county, July 22.
12	Argillaceous slate, from the outcrop of iron ore	do do do
13	Quartzite	Tomales bay
14	Limestone, red, with white veins	do
15	White limestone, with talc	do
16	Porphyritic and syenitic granite	Punta de los Reyes
17	Granitic rock	Near Sacramento valley
18	Granite	Macao, China
19	Granitic rock	Near San Amedio Pass, near the vein of antimony ore.
20	Granite	At the vein of antimony ore
21	Micaceous granite	do do
22	Granite, white and compact	Williamson's Pass
23	Graphic syenite	do
24	Fine-grained granite	Vallecito, south side of cañon, November 22.
25	Gneiss or mica slate	Vallecito
26	Granite, gray and fine-grained	Colorado desert, near Carrizo creek, Nov. 17.
27	Mica slate, compact and metamorphic	San Francisquito Pass, October 14
28	Slate, enclosed in granite	Near Fort Miller, July 30
29	Hornblende slate	San Francisquito Pass

I. GRANITIC AND METAMORPHIC—Continued.

No.	Name.	Locality.
30	Talcose slate	San Francisquito Pass
31	Serpentinoid rock	Near Moore's creek
32	Talcose rock, metamorphic	August 2
33	Talcose rock	do
34	Limestone, white, with blue veins, metamorphic	Calaveras county
35	Feldspar	Williamson's Pass
36	Granitic rock, (green)	do
37	Talcose slate	Four creeks, August 3
38	Quartzite, with talcose slate	do do
39	Picrolite ?	do do
40	———, metamorphic rock	Four creeks, August 2
41	Epidote and quartz	do do
42	Quartzite, metamorphic	do do
43	do do	Four creeks, August 4
44	Magnesian rock, serpentine	Four creeks
45	Magnesian rock, metamorphic	do
46	Slate containing Andalusite ?	July 22
(464)	Metamorphic rock	Mojave river, October 20
(465)	Metamorphic limestone	Peninsula Sierra, November 21

II. GREENSTONES, PORPHYRIES, VOLCANIC.

No.	Name.	Locality.
47	Syenite, boulder	Merced river
48	Diorite	do
49	Greenstone, porphyry, boulder	do
50	Porphyroid greenstone, boulder	do
51	Basaltic rock, boulder	do
52	do do	do
53	Green porphyry with hornblende crystals	do
54	Basaltic lava	Fort Miller
55	do	do
56	Vesicular lava	do
57	Basaltic lava	do
(463)	Basaltic nodule	do
58	Red vesicular lava	do
59	Trappean rock ?	Near Moore's creek, A, August 4
60	Volcanic rock	White creek
61	do	White creek, August 4
62	Compact trap rock	Near Moore's creek
63	do	do
64	Hornblende rock	Near Moore's creek, B, August 4
65	Metamorphic rock ?	Near Moore's creek, C, August 4
66	Trap rock	Four creeks
67	Bronzite	Mount Diablo
68	Serpentine	San Francisco
69	do	San Francisco, Fort Point
70	Serpentine with veins	New Almaden, San Jose
(406)	Serpentine with chrysotile or amianthus	

II. GREENSTONES, PORPHYRIES, VOLCANIC—Continued.

No.	Name.	Locality.
(407)	Serpentine	Fort Point
71	Trappean rock, ferruginous nucleus	Range next to the coast, October 31
72	Black vesicular lava	Colorado desert, near Carrizo creek
73	Light scoriæ	Tulare valley, near Tulare lakes
74	Glassy scoriæ, cellular	Colorado desert
75	Compact red scoriæ, with small cells	do
76	Pumice stone	Cohuilla villages
(466)	do	do
77	Volcanic slag, cinder	Colorado desert
78	Volcanic rock	Colorado desert, near Carrizo creek, Nov. 21.
79	Epidote, from an igneous vein	Fort Yuma, December 7
80	Porphyry, green and compact	Colorado desert
81	Black volcanic rock from the drift	Colorado desert, November 21

III. STRATIFIED ROCKS.

No.	Name.	Locality.
86	Blue sandstone	Yerba Buena island
87	do	do
88	do	Marion island
89	do	State's Prison
90	Blue sandstone, interior of a nodule	Benicia
91	Argillaceous and slaty sandstone	Alcatrass island
92	Cube of brown sandstone	Benicia
93	Shale, with lignite	Yerba Buena island
94	do	do
95	Jaspery rock, with white quartz veins	Lime point
98	Jaspery rock, green	Near Presidio, San Francisco
96	Jaspery rock, with white quartz veins	
97	Jaspery rock, with yellow veins	Lime point
99	Conglomerate	Benicia
100	Pebbles from the conglomerate	do
101	Sandstone	Livermore's Pass, west side
102	do	Livermore's Pass
103	Argillaceous sandstone	do
104	Sandstone containing pumice	July 13
105	Pumice stone	do
106	Sandstone	Stone house, July 21
107	do	Stone house
108	White sandstone, upper stratum	July 22
109	Sandstone, colored red by oxide of iron, containing pebbles of white quartz cap rock	do
110	White sandstone	Bear creek, July 22
111	do	do do
112	Red volcanic rock found in the sandstone	Bear creek
113	Slate, containing andalusite, found in the sandstone	do
114	Andalusite slate from the strata of sandstone	Chiastolite hill, Chowchillas river, July 23
115	Conglomerate formed of chiastolite crystals	do do
116	Argillaceous sandstone above clay	South side, July 30

III. STRATIFIED ROCKS—Continued.

No.	Name.	Locality.
117	Sandy clay	Bank of Tuoloumne river
118	Clay	Terrace at King's ferry
119	Clay from a well 80 feet deep	Lake Tent rancho, July 21
120	Sandstone containing casts of fossils, ferruginous	Ocoya creek
121	Selenite, (gypsum)	do
122	Fibrous selenite	do
123	Selenite in narrow plates	do
124	Sandstone with lines of oxide of iron	do
125	do do	do
126	Nodule of oxide of iron	do
127	Calcareous sandstone from the interior of the nodule of oxide of iron	do
128	Sandy strata showing a line of oxide of iron	do
129	Sandstone, gray and friable	do
130	White fine-grained argillaceous sandstone	do
131	Siliceous and argillaceous strata, white	do
132	White sandstone containing nodules, masses of clay	do
133	Conglomerate of pumice stone and charcoal, with volcanic ash	do
134	Conglomerate of pumice stone and charcoal, with volcanic ash	Ocoya creek
135	do do do do	do
136	Rounded water-worn fragments of pumice stone	do
137	Nodules of clay, from the strata	do
138	Compact arenaceous clay	do
139	Pebbles of greenstone and quartz, from the strata	do
140	Pebbles of porphyry and quartz	do
141	Compact calcareous sandstone from the interior of a nodule	do
142	Coarse-grained siliceous sandstone	Ocoya creek, right bank
143	Coarse-grained sandstone, hard and metamorphosed	do do
144	Coarse argillaceous sandstone	Ocoya creek
145	Conglomerate	do
146	Pumice stone masses in clay and sand	Fort Miller, south side, July 30
147	White siliceous earth, probably pulverized pumice	do do
148	Sandstone	Carrizo creek, November 21
149	Ferruginous sandstone	San Francisquito Pass
150	White calcareous sandstone	Los Angeles, October 31
151	White argillaceous rock	Near Los Angeles
152	Bituminous clay	San Pedro
153	do	do
154	Limestone, compact and gray, from the tertiary strata	do
155	Boulder of bituminous silica, semi-opal	do
156	Boulder of bituminous silica, showing the lines of deposition	do
157	Shale, charged with bitumen in seams and fissures	do
158	Bituminous shale	Los Angeles
159	do	Near Los Angeles
160	Selenite, from the strata	Punta Loma, San Diego
161	Conglomerate of pebbles cemented by carbonate of lime	Pilot knob, desert
162	Fine red clay	Alamo well, Colorado desert
163	Clay concretions	Colorado desert

III. STRATIFIED ROCKS—Continued.

No.	Name.	Locality.
164	Clay concretions	Colorado desert
165	do	do
166	Clay concretions, flat and thin	do
167	Clay concretions, ellipsoidal	do
168	Clay concretions, round, showing lines of stratification	do
169	Sandstone concretion, spherical	do
170	Sandstone concretion, formed of several flattened spheres	do
171	Sandstone concretion	do
172	Sandstone concretion, long flattened cylinder, showing lines of stratification	do
173	Sandstone concretion, long and elliptical, containing small concretions of peroxide of iron	Colorado desert
174	Cylindrical concretion	do
175	Concretion of peroxide of iron	do
176	Hollow concretion of peroxide of iron, showing lines of stratification	do
177	Pebbles of agate, jasper, and carnelian	do
178	Chalcedony	Yort Yuma
179	Black polished pebble	Desert north of Pilot Knob
180	Two polished pebbles	do do
181	Selenite	Desert, Carrizo creek
182	Sand	From the Sand-Hills, between Cook's Well and the Alamo, Colorado desert
183	Sand, from the drift at the deep well	Deep Well, Colorado desert
184	Sandstone, pink color	Mokelumne Hill
185	White sandstone	do
186	Gray sandstone	Bodega Bay
187	Argillaceous sandstone, green and soft; fossiliferous	Volcano Ridge, California
188	Fine clay, from the auriferous drift	Georgetown, California
189	Clay containing volcanic ash and the impression of a leaf, auriferous drift	do do
190	Red and drab clay, auriferous drift	Cement Hill, Georgetown, California
191	Sandstone, containing casts of tertiary fossils	Ocoya Creek, California
192	Rock, containing calcareous polythalamia	Monterey
193	Rock perforated by Petricola cylindracea	do
194	Sandstone	Bay of Panama
195	do	do
(462)	do	Bay of Panama, near the market
(463)	do	Barbacoas, Isthmus

IV. MINERALS AND ORES.

200	Sulphuret of antimony	Near San Amedio Pass
201	Sulphuret of antimony with quartz	do do
202	Vein-stone of the antimony ore, containing sulphuret of iron	Antimony Vein
203	Fragment of a small vein adjoining the vein of antimony	do
204	Hydrous peroxide of iron	Mariposa county
205	do do	do
206	Magnetic iron ore	Cañada de las Uvas
207	Magnetic iron ore with carbonate of lime	do do

IV. MINERALS AND ORES—Continued.

No.	Name.	Locality.
208	Magnetic iron with garnets	Williamson's Pass
209	——— ?	Between Vallecitos and San Felipe, Nov. 23.
210	Ferruginous quartz; auriferous?	Mariposa county, July 30
211	do do do	do do
212	Quartz; auriferous?	Near Howard's Ferry, Merced river
213	Fragment of a quartz vein; auriferous?	San Francisquito Pass
214	Copper ore	Great Basin, near Williamson's Pass
215	do	do do
216	do	do do
217	do	Williamson's Pass
218	do	do
219	do	do
220	Cinnabar	Near San José
221	Carbonate of magnesia in solid masses	Tulare Valley, near the Four Creeks
222	Native gold in quartz	Near Grass Valley
223	Fragment of quartz vein bearing native gold	Armagosa, Great Basin?
225	Ores of arsenic, lead and silver, from A. S. Taylor	Alisal, Monterey county
226	Bitumen	Los Angelos
227	do	do
228	Andalusite in conglomerate	Chiastolite Hill, Chowhillas river
229	Gypsum	Antimony mine
230	Chalcedonys and agates	Williamson's Pass, Bernadino Sierra
231	Silicified wood	Colorado Desert
232	do	do
233	do	do
234	do	Colorado Desert, north of Pilot knob
235	do	do
236	do	do
237	Fragment of fossil tree in sandstone, endogenous?	Near Merced river
238	Fragment of fossil tree perforated by Teredo	Near Merced river, July 22
239	Fossil wood lignite, from 80 feet below the surface in drift	San Francisco
240	Fossil wood	Placer county
241	do	Middle mines, California
242	Fossil wood, found 60 feet below the surface, presented by A. T. Langdon	Minnesota, northern mines
243	Fossil wood, charged with iron pyrites, in octahedral crystals	——— ——— ?
244	Silicified wood	Ocoya Creek
245	Lignite, showing lines of annual growth	Bellingham Bay
246	Lignite or brown coal, showing lines of annual growth	Near San Francisco
(460)	Lignite, found 110 feet below the surface	Grass Valley, Randolph Slide
247	Coal	Oregon
248	Bituminous coal	Bellingham Bay, W. T.
249	Travertine	San Felipe Creek
250	Travertine, from fissures of the granite	Pilot Knob
251	Calcareous incrustation, containing small fresh-water shells	Colorado Desert
252	Calcareous incrustation, resembling coral	do
253	Incrustation	Hot Springs, San Bernadino

IV. MINERALS AND ORES—*Continued.*

No.	Name.	Locality.
254	Rock charged with soluble salt	Mojave Valley
255	Soluble salts and efflorescences	Hot Springs, San Bernardino
256	Saline efflorescence	Borders of Kern Lake
(459)	Saline crust	Casteca Lake, Cañada de las Uvas
257	Travertine	Cascade creek, (Tejon.) Sept. 17
258	Saline crust	Cascade creek, (Tejon)
259	Saline incrustation	Santa Anna, San Bernardino, October 11
260	Salt, brought in by Lieutenant Williamson	August 29
261	Incrustation on the soil	Cohuilla villages, November 18
262	Saline deposit	Colorado desert, November 20
263	Soil	Cohuilla Valley, November 18
264	Soil, containing salts	Near Mojave river
265	Soil	San Bernardino
266	Subsoil	do
267	Stalactites cave in limestone	Cave city
268	Feldspar and quartz, cut by driving sand	Colorado desert
269	Feldspar and garnets, cut by driving sand	do

V. FOSSILS, SHELLS, AND MISCELLANEOUS.

No.	Name.	Locality.
270	Impressions of a plant, ligniform	Benicia
271	Impression of a plant, ligniform	do
272	Impression of a plant, in sandstone	Navy Point, Benicia
273	Impressions of leaves, in compact blue slate	Bellingham Bay, W. T
274	do do do	do
275	Fossil leaves in clay, overlying auriferous drift	Sacramento Valley
(404)	Impression of a leaf in clay	Mining claim, Georgetown
276	Cast of shell in sandstone	Panama
277	Fragment of fossil	do
278	Concretion in sandstone	Benicia
279	Casts of Turritella	do
280	do	do
281	do	do
282	Fossil crab, in argillaceous rock	Monterey
283	Infusorial earth	do
284	Infusorial earth, from the section	do
285	do do	do
286	do do	do
287	do do	do
288	do do	do
289	do do	do
(405)	Infusorial earth	San Luis Obispo
290	Rock containing Lutraria Traskei and Tellina congesta, Conrad	Between Carmello and Monterey
291	Scutella interlineata	Near San Francisco
292	Scutella in sandstone, under side	do
293	Scutella in sandstone	do
294	do	do
295	Scutella, under side	do
296	Sandstone, with Scutella and fragments of shells	do

V. FOSSILS, SHELLS, AND MISCELLANEOUS—Continued.

No.	Name.	Locality.
297	Sandstone, with Scutella and fragments of shells	Near San Francisco
298	do do do	do
299		
300	Sandstone, with cast of Trochus?	Benicia
301	do do	do
302	Mass of silicified stems	Kern river
303	Casts of fossils in sandstone	Volcano ridge
304	do do	do
305	Fragments of fossils in conglomerate	Volcano ridge, Placer county, 3½ miles east of Beale's bar.
306	Rock containing boring mollusks, Petricola and Saxicava	San Pedro
307	Turritella biseriata	San Fernando, October 31
308	Pecten and Natica	do do
309	Fragments of Ostrea and Pecten	do do
310	Cardita planicosta	
	Crassatella alta, Conrad	
	Dentalium and other shells	Cañada de las Uvas
311	Mass of shells, containing—	
	Dosinia alta, Conrad	do
	Cardium linteum, Conrad	do
	Natica œtites, Conrad	do
312	Meretrix Uvasana, Conrad	do
	Natica alveata, Conrad	do
313	Crassatella Uvasana, Conrad	do
314	——— ———?	do
315	Natica alveata, Conrad	do
316	do do	do
317	Fragments	do
318	Crassatella alta	do
	Turritella ———?	do
319	Turritella Uvasensis	
320	Busycon? Blakei, Conrad	
321	Sandstone containing fossils, Tellina & ———	Near Pass of San Amedio
322	do do do	do
323	do do do	do
324	Sandstone containing fossils and fragments	San Diego, near the Mission
325	Sandstone containing fossils—	
	Cardita	do
	Corbula	
	Axinea	
	Nucula	
	Astarte	
326	Nucula decisa? in sandstone	San Diego
327	Cardium modestum	do
328	Mass of shells—	
	Ostrea vespertina, Conrad	Carrizo creek
	Pecten Deserti, Conrad	do
329	Ostrea vespertina, Conrad (figured)	do

V. FOSSILS, SHELLS, AND MISCELLANEOUS—Continued.

No.	Name.	Locality.
330	Ostrea vespertina, Conrad (figured)	Carrizo creek
331	do do	do
332	Pecten Deserti, upper valve figured	do
333	Pecten Deserti, lower valve figured	do
334	Anomia subcostata, Conrad	do
335	Tellina congesta, Conrad	San Diego
336	Meretrix Tularana, cast	South end of Tulare valley
337	do do	do
338	Mytilus Pedroanus, Conrad	San Pedro
339	Tellina Pedroana, Conrad	do
340	Crepidula princeps, Conrad	Santa Barbara
341	Schizothœrus Nuttalli, Conrad	San Pedro
342	do do	do
343	Fissurella crenulata	do
344	Venerupis Pedroana, Conrad	
345	do do	do
346	Stramonita petrosa	South end of Tulare valley
347	Dentalium, cast of	do do
348	Arca microdonta, Conrad	Tulare valley
349	Meretrix Dariena, Conrad	Isthmus of Darien
350	Gratelupia mactropsis, Conrad	do
351	Zellina Dariena, Conrad	do
352	Modiola contracta, Conrad	Monterey co., 18 miles south of Trés Pinos
353	Meretrix Uniomeris, Conrad	do do
354	——— ———	Tomales bay
355	Parapholas spelœa	San Pedro
356	Anodonta Californiensis, Lea	Colorado desert
357	Buccinum interstratum, Conrad	San Pedro
358	Oliva Pedroensis, Conrad	do
359	Littorina ———	
360	Crucibulum spinosum	San Diego
361	Cast, Actæon	Ocoya creek
362	Cast	do
363	Cast	do
364	Cast of Turritella	do
365	Cast of Bulla	do
366	Cast of Oliva	do
367	Natica Ocoyana, cast.—See figure	do
368	Natica ———	do
369	Arca ———	do
370	do	do
371	Cast of outside of 370	do
372	Arca	do
373	Pecten catilliformis, Conrad	do
374	Pecten Nevadanus, cast	do
375	do	do
376	Pecten ——— ? cast	do
377	Pecten ——— ? cast	do

V. FOSSILS, SHELLS, AND MISCELLANEOUS—Continued.

No.	Name.	Locality.
378	Tellina Ocoyana, cast	Ocoya creek
379	do	do
380	do	do
381	Oliva ———, cast	do
382	Colus arctatus, cast	do
383	Solen ? cast	do
384	Conus ? cast	do
385	——— ———, cast	do
386	——— ———, cast	do
387	——— ———, cast	do
388	——— hinge and teeth, cast	do
389	Meretrix ? cast	do
390	do	do
391	do	do
392	do	do
393	Mactra ? cast	do
394	Casts of fragments	do
394 } 400 }	Casts of various species	do
401	Pebbles filled with silicified fossils, from the drift	Fort Yuma
402	Fragment of a human lower jaw, from a cave	Calaveras county
403	Human teeth and a perforated shell, from a cave	do
404	Impression of a leaf in clay	Mining claim, 80 feet below the surface, Georgetown.
405	Infusorial earth. (See after 289)	San Luis Obispo
406	Shark's teeth, (Echinorhinus Blakei)	Ocoya creek
407	Shark's teeth, (Scymnus occidentalis)	do
408	Shark's teeth, (Galeocerdo productus)	do
409	Shark's teeth, (Prionodon antiquus)	do
410	Shark's teeth, (Hemipristis heteropleurus)	do
411	Shark's teeth, (Carcharodon rectus)	do
412	Shark's teeth, (Oxyrhina plana)	do
413	Shark's teeth, (Oxyrhina tumula)	do
414	Shark's teeth, (Lamna clavata)	do
415	Shark's teeth, (Lamna ornata)	Benicia
416	Fragments of teeth of Zygobates	Ocoya creek
417	Ostrea	San Diego
418	Pecten latiuaritus, Conrad	do
419	Pecten (3)	do
420	Mytilus edulis, (1)	San Francisco
421	Modiola capax, Conrad	San Diego
422	Venus Nuttallii, Conrad	San Pedro
423	Venus fluctifraga, Sowerby	San Diego
424	Tapes grata, Say, T. discors., Sowerby, (Straminea, Conrad)	San Pedro
425	*Tapes gracilis, Gould	do
426	Cyclas, (imperfect)	Colorado desert
427	*Cardium cruentatum, Gould	San Diego
428	Lucina orbella, Gould	San Pedro

V. FOSSILS, SHELLS, AND MISCELLANEOUS—Continued.

No.	Name.	Locality.
429	Lucina Nuttallii, Conrad	San Pedro
430	Mesodesma rubrotincta, (?) Sowerby	do
431	Tellina vicina, Adams	San Diego
432	Tellina secta, Conrad	San Pedro
433	Sphenia Californica, Conrad	San Diego
434	Petricola cylindracea, Desh, (P. carditoides, Conrad)	Monterey—San Pedro
435	Solecurtus Californiensis, Conrad	San Diego
436	Gnathodon, Lecontei, Conrad	Colorado desert
437	Lottia scabra, Gould	San Francisco
438	Lottia patina, Eschholtz	San Pedro
439	Lottia mitra, Brod	do
440	Calyptrea hispida, Brod	San Pedro—San Diego
441	Crepidula incurva, Brod	San Pedro
442	Bulla nebulosa, Gould	San Diego
443	Bulla (Haminea) virescens, Sowerby	do
444	*Bulla (Haminea) vesicula, Gould	do
445	°Bulla (Tornatina) inculta, Gould	do
446	Trochus mœstus, Jonas	do
447	°Phasianella compta, Gould	do
448	Littorina, (undetermined)	
449	Melampus, (undetermined)	do
450	Oliva biplicata, Sowerby	San Pedro
451	°Potamis pullatus, Gould	San Diego
452	°Amnicola protea, Gould	Colorado desert
453	°Amnicola longinqua, Gould	do
454	°Planorbis ammon, Gould	Colorado desert—Ocoya creek
455	°Physa humerosa, Gould	Colorada desert
456	Succinea, (undetermined)	Ocoya creek
457	Serpentine, with thin seams of chrysolite or amianthus	Near San Francisco
458	Serpentine, from the interior of a globular mass	Fort Point
459	Saline crust. (See after No. 256)	Casteca lake, Cañada de las Uvas
460	Lignite. (See after No. 246)	Grass Valley
461	Sandstone	Barbacoas, (Isthmus)
462	Sandstone, (green)	Panama, near the market
463	Nodule of basalt	Fort Miller
464	Metamorphic rock	Mojave river, October 20
465	Limestone, (metamorphic)	Peninsula Sierra, November 21
466	Pumice stone	Colorado desert

DESCRIPTIONS OF SEVERAL OF THE SPECIMENS.

No. 1. *Granite, with hornblende and mica, summit of the Tejon Pass.*—This is a hard, compact rock, being a mixture of feldspar and hornblende in nearly equal parts, together with mica, which is not found in regular, detached crystals, but is disseminated in minute broken scales, which form films traversing the mass. A very decided structural arrangement of the minerals is apparent on the slightest inspection. They are all disposed in nearly parallel planes. The hornblende so far predominates that it imparts its color to the mass, and the feldspar appears as white disseminated grains. In color, the hornblende is dark-green, and is found in irregular crystals of various sizes, from a mere point to one-quarter of an inch in diameter. The mica has a dark bronzy-brown color.

No. 2. *Compact granite rock, Tejon Pass, near Station* 15.—This rock breaks up into rhombic and triangular masses, and is described in detail in chapter XV. The specimen is triangular, and shows the structure and composition of the whole rock very nearly.

No. 3. *White, crystalline limestone, Tejon Pass.*—This white limestone has such a beautifully even grain, and such a brilliant white fracture, that its adaptation to building purposes is at once apparent. There are no lines of structure in the specimen, and it is very homogeneous in its composition. It does not, therefore, present in itself any good evidence of a stratified origin.

No. 4. *Metamorphic sandstone, Tejon Pass, adjoining the limestone, (No.* 3.)—This specimen is grayish-white, and, although perfectly compact, has a peculiar granular structure and appearance. It looks like a hard silicious sandstone, but the grains are all closely united, so that they cannot be detached, and they do not feel sharp and harsh to the touch. When examined by the magnifying glass, many small transparent or translucent grains of quartz are seen. On one of the weathered surfaces there are many minute cells or pits, apparently formed by the decomposition of one of the composing minerals. One of the pits is rectangular, and may have been occupied by iron-pyrites. A fragment, on being treated with chlorhydric acid, effervesces slightly. It is probable that this rock is a metamorphosed calcareous sandstone.

No. 5. *Limestone, enclosing crystals of garnet—Tejon Pass, eastern base.*—The color of this limestone is not pure white, but is yellowish gray or drab. Its grain is not so even and brilliant as that of the limestone found further west, (No. 3.) The mass of the rock also appears much shattered and broken, and it is traversed with small seams and veins; the walls of some of them being lined with long crystals of calcite. A large number of brown crystallizations are also present in the specimen. These crystals are regularly formed rhombic dodecahedrons, and fuse readily before the blow-pipe flame to a vitreous globule. They are in all probability garnets; but they are not sufficiently compact and lustrous to be interesting as specimens.

No. 10. *Granite, July* 23.—This is a coarse grained rock, consisting of flesh-red feldspar and a dark brown mica, with a little hornblende and quartz. The minerals are dispersed in layers, but the structure is not very distinct.

No. 11. *Ferruginous slate—From the walls of the bed of iron ore, Burns' creek, July* 22.—This slate is so highly charged with iron, that it may be regarded as an iron ore; but the distinct lamellar structure of the slate is preserved. It has the dark brown color of the pure ore, and can be distinguished from it on inspection, only by its structure and lower specific gravity. The next specimen (No. 12) exhibits the slaty character perfectly, breaking into flat slabs and leaves. It has a bluish-gray, or mouse color, on freshly broken surfaces. Small rusty cavities spread over the surface indicate the former presence of iron pyrites. These cavities are not

rectangular but spherical, and are not larger than the section of a pin. It is a clay-slate, and undoubtedly of sedimentary origin.

No. 13. *Quartzite.—Tomales bay.*—It is difficult to give a description of this specimen. Although principally composed of quartz of a light gray color, it has an exceedingly regular structure like stratification, and this character is given to the mass by the presence of layers of delicate glassy crystals, the nature of which it is not possible to determine. They may be the faces of the grains of quartz, but they appear to cleave like feldspar, and when the mass is held in certain positions they reflect the light in long lines. These reflecting lines are about one-sixteenth of an inch and parallel. The rock is probably metamorphic. It was presented to me, with No. 14, by Dr. A. Randall, of Punta de los Reyes.

No. 14. *Red Limestone.—Tomales bay.*—This limestone has a dark, chocolate red color, and is irregularly veined with white and dark brown lines. It is compact and capable of taking a high polish, and may be considered as a beautiful ornamental marble. It occurs in considerable quantities, but whether large blocks suitable for building can be quarried there had not been determined when the specimen was procured. Its position on the waters of Tomales bay renders it easy of access, and it can be readily transported to San Francisco.

No. 15. *White Limestone or Dolomite.—Tomales bay.*—This specimen is from the shores of Tomales bay, on the west side, where the rock occurs in considerable quantity, and is used for making caustic lime. It is white, coarse-grained; the crystals large, and showing curved surfaces when cleaved. Small, irregular patches and tufts of talc are found in the mass, and this, with the fact that the crystals have curved faces, leads me to consider the limestone as magnesian—a dolomite; but this has not been determined by analysis. Small scales of graphite are also disseminated in the mass. It is probably a metamorphic limestone.

No. 16. *Porphyritic Granite.—Punta de los Reyes.*—This specimen, which was taken from the quarry, does not show as much hornblende as is usually found in the rock of that locality, and the specimen consequently presents a lighter color than the mass of the rock. A distinct crystal of feldspar, one inch in length, is seen in the mass, and this includes small crystalline masses of hornblende or magnetic iron, entirely isolated in the spar. A very dark colored mica, in indistinct scales, is found in the mass.

No. 18. *Granite—Macao, China.*—This is a specimen of the rock which is so extensively used in San Francisco for buildings. It has a very pleasing pinkish-gray color, and a very even and desirable texture. Feldspar and quartz are the predominating minerals. Little or no hornblende can be seen, but the gray color is produced by the isolated crystals of black mica which are very compact and small; so compact that the edges greatly resemble cleavage surfaces of hornblende.

No. 22. *White Granite—Williamson's Pass.*—This rock, at first sight, looks like a granular limestone or sandstone, but on examination the presence of a large amount of white glassy feldspar is proved by the reflection of light from the cleavage surfaces. Grains of white and translucent quartz are seen mingled with the spar, and very small fragmentary scales of a white, silvery mica. The rock is exceedingly compact and homogeneous.

No. 23. *Graphic Syenite—Williamson's Pass.*—This rock is a mixture of green hornblende and purplish feldspar; the hornblende being disposed in irregular but angular crystals, the fractured or polished surface of the rock presents the appearance of Hebrew or Chinese characters.

No. 30. *Talcose Slate—San Francisquito Pass.*—This slate is light-green and consists chiefly

of talc, and closely resembles the talcose slates of the gold region of the Sierra Nevada and Appalachian chain. Exactly similar slates occur in the Carolinas.

Nos. 31 and 32. *Talcose Rocks—Tulare Valley, Aug.* 2.—These two specimens are from the same locality and differ but slightly. They are magnesian and consist of serpentine and talc traversed by quartz veins. The rock is probably metamorphic.

No. 34. *White crystalline Limestone traversed by blue veins—Calaveras Co.*—This is a characteristic specimen of the white limestone—commonly called cave limestone—which forms an extensive belt on the western flank of the Sierra Nevada. It is compact and has an exceedingly fine grain, not distinctly crystalline, and is an excellent and durable material for building. It is regularly veined with blue in long bands and lines which are sometimes oblique, and closely resemble the lines of deposition in sandy strata. The rock, notwithstanding these veins, appears to weather very evenly, there being little or no difference in hardness or composition. Beautiful slabs of marble can be obtained from this material, as its compact texture is favorable to its taking a high polish, and the blue veins give it an interesting appearance. There are no indications of fossils or their remains in the specimen, nor were there any found in the rock, although an extended surface was examined. This is the limestone in which the great cave of Calaveras Co. is formed. It is in all probability a metamorphic rock, but its geological age cannot be readily established in the present state of our knowledge of that region.

No. 38. *Quartzite with Talcose Slate—Four Creeks.*—This specimen is nearly all quartz, but it appears in contorted layers like a slate. It is, in fact, interstratified to a slight degree with softer material, probably talcose slate, in which it is found. The weathered surface shows a succession of regular layers; but the cross-fracture shows a compact, homogeneous mass of quartz.

No. 39. *Picrolite—Four Creeks, Aug.* 3.—This specimen is a green, fibrous, or columnar mass, resembling the picrolite of the southern counties of Pennsylvania. The mass does not separate into fine silky fibres like asbestos, but is hard and compact. It has an oil-green color like that of precious serpentine. The direction of the fibres is oblique to the side of the specimen.

No. 40. *Metamorphic* [?]*—Four Creeks, August* 2.—This rock is dark-green and compact, and resembles a greenstone or trap. It, however, has a laminated structure or slaty stratification, which, with its association, causes me to refer it to the metamorphic rocks, although from the specimen alone I should be inclined to consider it eruptive. I am more inclined to this view, as specimen No. 63, which I marked at the locality as eruptive, has very similar mineral characters.

Nos. 42 and 43. *Quartzite—Four Creeks.*—These two specimens have a general and, indeed, close resemblance. No. 43 exhibits the granular structure of sandstone very clearly, but it is perfectly hard and compact, all the grains being thoroughly cemented together. No. 42 is still more thoroughly metamorphosed, and the grains are not so distinctly seen.

No. 46. *Slate containing Andalusite—Crossing of the Chowhillas River.*—This slate was taken from the strata of sandstone and conglomerate on the banks of the Chowhillas, in which it is very abundant. It is dark-bluish gray—the ordinary "slate-color"—and is charged with small crystals of andalusite or macle. The quantity of the slate in these strata shows that it must exist in very considerable quantities on the slope of the Sierra Nevada, in that region.

No. 86. *Blue sandstone—Yerba Buena Island, and Francisco Bay.*—This is a fair specimen of the compact blue sandstone of San Francisco and its vicinity, which is so much used for build-

ings. A full description of the general characters of the rock, as shown at different points, has already been presented. It much resembles a trappean rock, for which it would readily be mistaken, in hand specimens, unless the attention was specially directed to its granular structure. Specimens from several localities are in the collection, together with masses of the associated shales and the metamorphosed portions—the prasoid and jaspery rocks.

Table showing the elevation above the sea of the principal places mentioned in the report.[1]

	Feet.
Mount Diable—Diablo Range, (Beckwith)	3,960
Madelin Pass, Sierra Nevada, latitude 40° 44′ 12″	5,667
Plateau of the Sierra Nevada, (Beckwith)	5,440
Second summit of Madelin Pass, (Beckwith)	5,596
Noble's Pass, Sierra Nevada	6,074
Carson Pass, Sierra Nevada, latitude 38° 42′ 15″, (Goddard)	7,972
Breccia Pass, near the middle fork of the Stanislaus river, (Goddard)	10,150
Walker's Pass, Sierra Nevada, latitude 35° 39′	5,306
Humpahyamup Pass, latitude 35° 33′ 38″	5,351
Taheechaypah Pass, latitude 35° 07′ 28″	4,008
Tejon Pass, latitude 35° 02′ 47″	5,364
Cañada de las Uvas, latitude 34° 54′ 40″	4,315
Cajon de Zenoco—Bernardino Sierra	4,256
San Francisquito, Bernardino Sierra	3,445
Williamson's, (new Pass,) Bernardino Sierra	3,164
Cajon Pass, Bernardino Sierra	4,676
San Bernardino or San Gorgoño, Peninsula Sierra	2,808
Warner's Pass—Peninsula Sierra, leading from the Colorado Desert to San Diego	3,780
San Fernando Pass, between San Francisquito Rancho and San Fernando	1,940
Livermore's Pass, Diablo Range, south of Mount Diablo	686
San Bernardino Mountain, Bernardino Sierra, (elevation undetermined probably)	8,500
San Gorgoña Mountain, Peninsula Sierra, (elevation undetermined probably)	7,500
San Amédio Mountain, at the head of the Tulare Valley, (about)	7,000
Fort Miller, on the San Joaquin river, (about)	402
Plain of Basaltic lava at Fort Miller	1,200
Ocoya Creek Depot Camp	738
Tops of the tertiary hills at Ocoya Creek, (about)	1,300
Tejon Depot Camp	1,447
Buena Vista, or Kern Lake	398
Dry Lake, in the Great Basin east of the Tejen Pass	2,380
Soda Lake, at the sink of the Mojave river	1,137
Camp on the Mojave river	2,664
Lake Elizabeth, near the Pass of Francisquito, (about)	3,000
Plain of San Fernando	1,048
Valley of the Santa Anna, at San Bernardino	1,118
Deep Well, at the margin of the Colorado Desert	160
Valley of the Ancient Lake, Colorado Desert. This depression is estimated below the level of the sea.	
Big Lagoon, Colorado Desert	70
Fort Yuma, junction of the Gila and Colorado	108
San Felipe Valley, Peninsula Sierra	2,176
Warner's Valley, or Rancho, near Agua Caliente	2,911

[1] Most of these elevations were determined by the Expedition, and are taken from the tables.

ARTICLE VII.

DESCRIPTIONS OF PLANTS COLLECTED ALONG THE ROUTE, BY W. P. BLAKE, AND AT THE MOUTH OF THE GILA.

BY JOHN TORREY.

Mr. Blake, the geologist of the Expedition commanded by Captain Williamson, having requested me to examine and report on the plants that he found in his explorations, as well as those collected near Fort Yuma, by Major Thomas and Lieutenant Du Barry, of the United States army, I have prepared the following list. The drawings for the illustrations were made by Mr. E. Dwight Church, a young artist of this city, and the engraving was executed by Mr. Prestele.

JOHN TORREY.

NEW YORK, *May* 1, 1857.

ARGEMONE MEXICANA, *Linn.* On the Colorado, and in other parts of California. An extremely hispid white flowered variety, which seems to be the same as A. munita, *Durand & Hilg. Pl. Herm.*

NASTURTIUM OBTUSUM, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 74. With the last, in wet places. Flowers through the summer.

SISYMBRIUM DEFLEXUM, *Harv.; Torr. in Bot. Whipp. Rep.* Sandy places in the Colorado. Varies greatly in size.

DITHYRÆA CALIFORNICA, *Harv. in Hook. Lond. Jour. Bot.* 4, *p.* 77. *t.* 5 ; *Torr. in Bot. Whipp. Rep.* California desert ; March.

OLIGOMERIS GLAUCESCENS, *Camb.; Gray, Pl. Wright,* 2, *p.* 16. Dry places between the Colorado and the sea coast ; April, June.

SESUVIUM PORTULACASTRUM, *Linn.; DC. Prodr.* 3, *p.* 453 ; Var floribus subsessilibus, *Gray, Pl. Wright,* 1, *p.* 13. Flowers on short pedicels. Stamens about 50. Sandy banks of the Colorado.

FAGONIA CALIFORNICA, *Benth. Bot. Sulph. p.* 10. Near Fort Yuma. This species is, as Bentham remarks, closely related to F. Chilensis and F. Cretica ; but we think it more closely approaches the former than the latter. (Tab. I.)

LARREA MEXICANA, *Moricand ; Torr. in Emory's Report, p.* 137, *t.* 0. This is the well known *Creasote-plant* or *Creasote bush.* It grows from four to six feet high. It is very common in the desert west of the Colorado, and in barren spots on the mountains near that river.

SPHÆRALCEA INCANA, *Torr. in Gray, Pl. Fendl. p.* 23 ; *Gray, Pl. Wright, p.* 21. River allu-

vions on the Colorado; beginning to flower in January. Resembles the original specimens collected on the Gila by Major Emory.

SIDA HEDERACEA, *Torr. in Pl. Fendl. p.* 23. River bottoms near Fort Yuma, and west to the Pacific; August, September.

HIBISCUS DENUDATUS, *Benth. Bot. Sulph. p.* 7, *t.* 3. California desert, January, May.

DALEA EMORYI, *Gray, Pl. Thurb. p.* 315. Sandy soils on the Colorado and Gila. This and the following species, viz: D. spinosa, *Gray;* D. scoparia, *Gray;* D. frutescens, *Gray;* D. arborescens, *Torr.;* D. Fremontii, *Torr.;* and D. Schottii, *n. sp.*, form a peculiar group, intermediate between Dalea and Psoralea, distinguished from the former by the truly papilionaceous corolla, and by all the petals being inserted at the base of the calyx; from the latter, (at least the North American species,) in habit, in the monadelphous stamens, the upper part of the filaments being distinct, and in other characters. Other remarks on this group will be made in the botany of the Mexican Boundary Survey. (Tab. II.)

DALEA MOLLIS, *Benth. Pl. Hartw. p.* 306. With the last; a smaller plant than the New Mexican variety.

CERCIDIUM FLORIDUM, *Benth. Mss.; Gray, Pl. Wright, p.* 58, (*adnot.*) On the Colorado, and in the desert west. It is called *Palo verde* by the Mexicans, and *Green Acacia* by the Americans. It sometimes attains the height of 30 feet. (Tab. III.)

LUPINUS SPARSIFLORUS, *Benth. Pl. Hartw. p.* 303. On the Colorado. Less hairy than the plant described by Bentham.

STROMBOCARPA PUBESCENS, *Gray, Pl. Wright,* 1, *p.* 60. Prosopis (Strombocarpa) pubescens, *Benth. in Lond. Jour. Bot.* 5, *p.* 82. This is the well known *Screw-bean* of travellers in New Mexico and California. It occurs from the Rio Grande to the western slope of the Cordilleras of California. The pods are an important article of food to the Mexicans and Indians, and are also greedily eaten by cattle. (Tab. IV.)

OPUNTIA TESSELLATA, *Engelm. Syn. Cact. p.* 53, *& in Cact. Whippl. Pacif. Railroad Surv. t.* 21. Desert west of the Colorado. A remarkable species; well described and figured by Engelmann.

MAMMILLARIA PHELLOSPERMA, *Engel. Cact. Mex. Bound. p.* 6, *t.* 7. Common on the Colorado.

MENTZELIA ALBICAULIS, *Torr. & Gray, Fl.* 1, *p.* 534. Sandy soils; from the Gila to San Diego; beginning to flower when scarcely an inch high.

MENTZELIA PUMILA, *Nutt. in Torr. & Gray, Fl.* 1, *c.* On the Colorado; beginning to flower in March. This agrees with Nuttall's original specimens, and with others collected in California by Frémont.

ŒNOTHERA (CHYLISMIA) CLAVÆFORMIS, *Torr. & Frem. in Frem. 2d Rep. p.* 314. With the last. Anthers hairy. We fear that R. brevipes of the Botany of Whipple's Expedition is a state of this species with considerably larger flowers and short pedicels. Intermediate specimens seem to connect them. We have a remarkable variety, collected by Frémont in 1849, (probably on the Lower Gila,) in which the lamina of the leaf is more than six inches long, deeply pinnatifid, the segments very unequal and coarsely toothed, the terminal one scarcely larger than some of the others.

ŒNOTHERA (CHYLISMIA) CARDIOPHYLLA (n. sp.): annua, caule folioso parce ramoso; foliis cordatis repando-dentatis, petiolo nudo; capsulis elongato-cylindricis subsessilibus v. pedicello 3–4-plo longioribus. Near Fort Yuma. Whole plant, when young, clothed with a soft white pubescence, most of which disappears with age. Stem 6-12 inches high. Leaves deeply cordate,

about an inch in diameter, acutely repand-toothed; the petiole usually a little longer than the lamina, and the lower ones sometimes twice as long. Flowers few, in a loose terminal raceme, the lower ones often axillary; upper ones subtended by small foliaceous bracts. Pedicels sometimes very short, but more commonly one-third or one-fourth the length of the ovary. The free portion of the calyx-tube about one-third the length of the ovary. Petals broadly obovate, entire, 4 or 5 lines long, at first yellow, but turning rose-color after flowering. Stigma capitate. Capsule 1 or 1½ inch long, and about a line in diameter; acute at the base. Seeds obovate; testa membranaceous. This species differs from Œ. clavæformis and Œ. brevipes in the cordate leaves and naked petioles. From Œ. scapoidea in the leafy stem, the form of the leaves, the elongated linear capsules, and the shorter pedicels.

AMMANNIA LATIFOLIA, *Linn.; Torr. & Gray, Fl.* 1, *p.* 480. On the Lower Colorado. Resembles the eastern plant, except that the style is shorter.

PHORADENDRON CALIFORNICUM, *Nutt. in Jour. Acad. Phil. n. ser.* 1, *p.* 185. With the last.

PHORADENDRON FLAVESCENS, var. GLABRIUSCULUM, *Engelm. in Gray, Plant. Lindh.* 2, *p.* 212. On the Mesquite, (Algarobia glandulosa); rarely on Cotton-wood.

PECTIS PAPPOSA, *Harv. & Gray, in Gray, Pl. Fendl. p.* 62. California desert. It is called Mansanilla coyote by the Mexicans.

MACHÆRANTHERA CANESCENS, var. LATIFOLIA, *Gray, Pl. Wright,* 2, *p.* 75. Alluvial banks of the Great Colorado; Sept.–Oct. Stem 1-2 feet high.

PALAFOXIA LINEARIS, *Lagasca; DC. Prodr.* 5 *p.* 124. Desert west of the Colorado. Stem 1-2 feet high. Flowers pale purple.

CHENACTIS TENUIFOLIA, *Nutt.; Torr. & Gray, Fl.* 2, *p.* 370. Near Fort Yuma. All the specimens were small and slender. Leaves mostly simply pinnatifid, the few divisions scarcely more than half a line wide. Ray and disk-flowers nearly equal. Pappus of 4 nearly equal ovate-lanceolate acuminate scales.

TRICHOPTILIUM INCISUM, *Gray, in Bot. Mex. Bound. ined.* Psathyrotes incisa, *Gray, Pl. Thurb.* In the Colorado desert, California, where it was first discovered by Mr. Thurber, and afterwards by Lieut. Du Barry and Mr. Schott. We have received the plant from no other station. (Tab. V.)

TESSARIA BOREALIS, *Torr. & Gray, in Emory's Rep. p.* 143; *Torr. in Sitgr. Rep. t.* 5. Cariso creek, and in all wet places, from the Colorado to the mountains east of San Diego.

EREMIASTRUM BELLIOIDES, *Gray, Plant. Thurb. p.* 321. Desert west of the Colorado. Our specimens are much more advanced than those collected by Mr. Thurber, but we have nothing to add to Dr. Gray's description except what may be derived from our figure. (Tab. VI.)

BAILEYA MULTIRADIATA, *Harv. & Gray, Pl. Fendl. p.* 106, *adnot.* Near Fort Yuma. B. pleniradiata seems to be scarcely distinct.

BACCHARIS CÆRULESCENS, *DC. Prodr. p.* 402. Banks of the Colorado; mostly in the vicinity of water-holes, but sometimes in dry places. The plant is often 14 or 15 feet high, and much branched. The leaves vary from entire to acutely dentate-serrate.

BACCHARIS EMORYI, *Gray, in Bot. Whipple's Exped.* With the last. Resembles B. angustifolia.

ENCELIA CONSPERSA, *Benth. Bot. Sulph. p.* 26. With the last.

FRANSERIA HOOKERIANA, *Nutt. in Torr. & Gray, Fl.* 2, *p.* 294. A common weed on the Lower Gila, and west to the Pacific.

HYMENOCLEA MONOGYRA, *Gray.* With the last. In some of the specimens the scales of the involucres are spirally disposed, showing a tendency to pass into H. Salsola, which we suspect may prove to be an abnormal state of H. monogyra.

PERITYSE EMORYI, *Torr. & Gray, in Emory's Rep. p.* 142. On both sides of the Colorado, and west to the mountains. The characters seem to be constant.

ASCLEPIAS (OTARIA) SUBULATA, *Decaisne in DC. Prodr.* 9, *p.* 571. In the desert; not uncommon. It occurs also in Lower California. This is the species which, in the botany of Whipple's expedition, we suspected might be A. subulata. We now possess better specimens, with the leaves, and have scarcely a doubt that it is the species described by Decaisne under that name, notwithstanding the description does not apply in all respects. The stem is erect, 2-4 feet high, straight, simple, or sparingly branched above, either smooth and glaucous, or somewhat pubescent. The leaves are almost filiform, and erect; the lower ones nearly two inches long. Umbels sometimes solitary, but more commonly several in a terminal panicle, 10–20-flowered; peduncles 1–2 inches long, erect; pedicels 6–8 lines long, and like the peduncles, pubescent. Flowers about as large as in A. variegata. Sepals broadly ovate, acute. Petals (apparently white) ovate-oblong, rather acute, reflexed. Hoods of the crown twice as long as the nearly sessile gynostegium, dilated above, slightly toothed at the summit; horn somewhat exserted. Follicles about 4½ inches in length, narrowly oblong, acute at the base, much attenuated above, smooth and even. (Tab. VII.)

SARCOSTEMMA HETEROPHYLLUM (*Engelm. Mss.*): volubile, glabrum; foliis petiolatis inferioribus lineari-lanceolatis hastatis, superioribus linearibus; pedunculis glabris elongatis folia superantibus; pedicellis calycibusque pubescentibus; corolla rotata glabra, margine fimbriata coronæ interioris lobis ovato-globosis gynostegii subbreviores. Near Fort Yuma; August–September. Stem 10–20 feet long. Lower leaves cordate-hastate at the base, 2–3 lines wide, the upper ones merely obtuse at the base, and 1–1½ line wide. Flowers pale purple. This is 1679 of Wright's New Mexican collection.

LIPPIA NODIFLORA, *Michx, Fl.* 2, *p.* 15. Alluvial banks of the Colorado; flowering through the summer. The leaves vary considerably in form. Some of the specimens show a transition to L. lanceolata.

NAMA BIFLORA, *Choisy in DC. Prodr.* 10, *p.* 183; var. SPATHULATA, *Torr. in Capt. Parke's Rep.* California Desert; flowering through the summer.

NICOTIANA MULTIFLORA, *Nutt. Plant. Gamb.*? On the Colorado and in other parts of California; September. We cannot be sure that this is Nuttall's plant. It is about 2 feet high, minutely pubescent, viscid on the upper part of the stem. The radical leaves are wanting in the specimens; the cauline are 2 inches long, oblong-spatulate entire, clasping and auriculate at the base. Flowers in a loose panicle; the pedicels 2–4 lines long. Calyx campanulate, the 5-cleft segments lanceolate and nearly equal. Corolla tubular, with a small, somewhat spreading border, about 8 lines long, pale dull yellow. Capsule 2-valved, the valves deeply 2-parted. It seems to belong to the section Rustica of Dunal.

PHYSALIS. Three species were found near Fort Yuma by Major Thomas, but we have laid them aside until we make an examination of all the North American species of this puzzling genus.

DATURA THOMASII (n. sp.): annua, caule erecto (humili); foliis ovatis repandis v. sinuato-dentatis glabriusculis; floribus brevi-pedicellatis; corolla calyce pentagono acute dentato duplo longiore; capsula globosa nutante aculeata, aculeis validis pubescentibus. Near Fort Yuma; Sept.-Oct. Stem 12-18 inches high. Flowers nearly one-third smaller than in D. Stramonium. Corolla white, tinged with purple on the inside, near the summit. Fruit, (without the prickles,) about an inch in diameter. Seeds blackish, tuberculate-rugose. This appears to be different

from any Datura described by Dunal. We have received it only from the Great Colorado. Specimens collected by Mr. Schott have the spines less thickly set, and the leaves more strongly toothed.

LYCIUM BARBINODE, *Miers, Ill. South Am. Bot.* 2 *p.* 115, *t.* 68, *E.* Colorado Desert; March.

MOHAVE VISCIDA, *Torr. & Gray, Bot. Whipple's Rep.* With the last. Flowers apparently sulphur-yellow, speckled towards the base with purple. The prominent palate saccate, purple, bearded with yellow hairs. Style cylindrical, nearly as long as the stamens; stigma capitate. The fruit of this remarkable plant is not yet known, but there can now remain little doubt of its having been rightly placed near Martynia.

PHACELIA CILIATA, *Benth. in Trans. Linn. Soc.* 17, *p.* 280. Near Fort Yuma. This species is to us one of the rarest of the genus.

GILIA LINIFLORA, *Benth. l. c. in DC. Prodr.* 9, *p.* 315. San Matio, near San Francisco.

FOUQUIERA SPLENDENS, *Engelm. in Wisliz. Mem. N. Mex. p.* 98 On the Colorado and Lower Gila, westward to the mountains.

ERITRICHIUM ANGUSTIFOLIUM (n. sp.): annuum, pilis patulis hispidissimum; caule e basi ramoso; foliis linearibus; racemis paucifloris; floribus sessilibus, calyce hispido, sepalis lanceolato-linearibus; corolla hypocraterimorpha (alba); nuculis ovatis acutis minutissime granulatis. With the last. Plant 6–12 inches high, slender, the lower branches often prostrate, hispid with white (or, on the inflorescence, yellowish) spreading hairs. Leaves an inch or more in length, and scarcely a line wide. Racemes about half an inch long, the flowers closely approximated. Sepals very hispid. Corolla white, falling early, less than a line long; segments of the limb obovate, very obtuse and entire. Stamens with very short filaments, which are inserted near the base of the tube. Nutlets extremely minute, convex, and minutely papillose on the back, acutely angular on the face, one or more of them often abortive. This species is not rare in California, and I think it occurs also in Oregon. There are specimens of it in the herbarium of the Philadelphia Academy of Natural Sciences, named by Nuttall, "Myosotis (Aphanisma) pygmæa," but the plant is evidently an Eritrichium, as that genus is now characterized. The manuscript specific of Nuttall is changed, because it is not applicable.

PECTOCARYA LINEARIS, *DC. Prodr.* 10, *p.* 120. Near Fort Yuma. The specimens agree with Chilian ones in our herbarium.

HELIOTROPIUM CURASSAVICUM, *Linn.*; *DC. Prodr.* 9, *p.* 538. Common in most places where the soil is saline, from the Colorado to the Pacific.

ACANTHOGONUM RIGIDUM, *Torr. Bot. of Whipple's Rep.* Near Fort Yuma. The specimens are in an early state, and enable us to correct and complete the characters of this genus, as given in the work just quoted. We have also seen a specimen of the plant in a small collection made by A. B. Gray, Esq., while making the survey of a route for a Southern Pacific Railroad, near the parallel of 32°. The plant seems never to attain a greater height than about 3 inches; beginning to flower immediately above the cotyledons. It is furnished with both radical and cauline leaves, which are ovate or obovate, half an inch long, mostly obtuse; the base tapering to a petiole which is about twice the length of the lamina. Involucres in axillary sessile clusters, subtended by long straight subulate and spine-like divaricate bracts. Involucre always 3-cleft; the segments very unequal, one of them sometimes much elongated, straight. Perianth yellow, campanulate-funnelform, hairy at the summit. Stamens 9, included: filaments inserted at the upper part of the tube. Ovary oblong, acute at each end, rough on the angles towards the summit.

ACANTHOGONUM? CORRUGATUM (n. sp.): caule superne trichotome ramoso; bracteis brevibus recurvis; fasciculis involucrorum pedunculatis; involucri laciniis subfoliaceis subæqualibus spinescentibus. apice incurvis, tubo cylindrico corrugato. Near Fort Yuma. This species seems to be almost intermediate between Acanthagonum and Chorizanthe. It has the habit of the former, with the cylindrical tube and incurvate tips of the involucre of the latter. But the involucral segments are never more than three, and the filaments are not inserted near the base of the perianth, as in Chorizanthe, but high up in the tube. Plant only two or three inches high.

CHORIZANTHE FIMBRIATA, *Nutt. Pl. Gamb. in Jour. Acad. Phil.* (*n. ser.*) 1, *p*, 168; *Benth. in DC. Prodr.* 14, *pars* I, *p.* 25. California Desert, and on Pacific coast. (Tab. VIII.) This belongs to a section of the genus Ptilosepala, by Nuttall. A second species discovered by Dr. Antisell, in Parke's expedition, near San Felipe, it will be described and figured in the botany of that expedition, under the name of C. laciniata.

ERIOGONUM THOMASII (n. sp.): annuum foliis radicalibus rosulatis longe petiolatis ovatis supra pubescentibus subtus albo-lanatis; scapo trichotome ramosissimo glaberrimo, ramis capillaribus, involucris longe filiformi-pedunculatis late campanulatis 5-dentatis 8–10-floris, bracteolis cuneato-oblongis obtusis, margine longe pilosis, perigoniis basi extus pubescentibus, laciniis exterioribus subpanduriformibus, interioribus lineari-oblongis. Near Fort Yuma. Also found by Colonel Frémont, probably on the lower part of the Gila, in 1849. Plant about a span high; leaves 6–8 lines long; the petioles varying from half an inch to an inch in length. Branches of the scape widely spreading. Peduncles 4–8 lines long. Involucres scarcely half a line long, deeply 5-toothed. Flowers nearly as large as the involucre, glandularly pubescent at the base, the pedicels articulated close to the perianth. Divisions of the perianth very obtuse; the exterior cordate at the base and reflected at the sides, a little emarginate; the inner about one third longer than the exterior ones. Filaments and ovary glabrous. Fruit not seen. Resembles E. trichopodum, but that species has the flowers strongly hairy on every part, acute and nearly equal segments of the perianth, and narrowly linear bracteoles.

SALICORNIA FRUTICOSA, *Linn*? Cañada de las Uvas, in saline soils; California. The specimens are not sufficient for accurate determination; but the plant appears to be identical with the common frutescent species.

SCHOBERIA CALCEOLIFORMIS, *Moq. in DC. Prodr.* 13, *pars* I, *p.* 166. With the last. Moquin states that this plant has been found near New York, which must be a mistake.

EUPHORBIA ALBOMARGINATA, *Torr. & Gray, Bot. Pope's Rep. p.* 18. Alluvial soils near the Colorado; September.

EUPHORBIA POLYCARPA, *Benth. Bot. Sulph. p.* 50. With the last.

EUPHORBIA SETILOBA (*Engelm. Mss.*): "prostrata, pilis brevibus patulis sæpe glanduliferis tota puberula; foliis minutis e basi vix obliqua subcordata ovatis obtusis; stipulis minutis deciduis; glomerulis lateralibus; involucris dorso profunde fissis, appendiculis in lacinias 3–4 subulatas divisis; stylis elongatis fere ad basin bifidis, stigmatibus clavellatis divaricatis; capsula hispidula; seminibus ovatis acutatis transverse rugulosis." Near Fort Yuma. Stem 3 inches long. Leaves 1 line long, reddish. Appendages of the glands white, very conspicuous, almost setaceous. There are only about three male flowers in each involucre.

OREODAPHNE CALIFORNICA, *Nees, Syst. Laur. p.* 463. Martinez, California. In that region the plant is scarcely a tree, the height being only from 10 to 20 feet. The inhabitants know it by various names, such as mountain laurel, balm of heaven, spice bush, &c. The Spaniards

are said to use the dried and pulverized leaves as a condiment. The fruit is nearly globose, about the size of an ordinary plum, and when ripe, (which is about the middle of July,) of a dark purple color.

QUERCUS HINDSII, *Benth. Bot. Sulph. p.* 55. Q. longiglanda, *Torr. in Frem. Geogr. Mem.* Q. Ransomi, *Kellogg, in Proceed. Calif. Acad. Nat. Sc., p.* 25? With the next; bearing its long ripe acorns in October.

QUERCUS CRASSIPOCULA (n. sp.): foliis perennantibus coriaceis petiolatis oblongis acutis integerrimis v. parce acuteque dentatis subtus pubescentibus demum glabris; fructibus sessilibus, cupula depresso-hemispherica crassissima, squamis latissimis tomentosis brevi-acuminatis glanda, ovata glabra. (Tab. IX.) Tejon Pass. This handsome evergreen oak is usually but a middle-sized tree. It is certainly very near Q. densiflora, *Hook. & Arn.*, of which I have no good acorns for comparison. That species (judging from the figure of *Hooker, Ic., t.* 380,) has smaller acorns, a thin, hemispherical cup, and narrow scales. The leaves vary in size and form; on young shoots they are often sharply dentate. The cups are sometimes nearly an inch and a half in diameter, and extremely thick, with a rounded margin. The scales are broader than long, and have a small, abrupt point. The lower ones, and sometimes all of them, are more or less thickened and pulvinate, so that they give to the cup a tuberculate appearance. Gland often an inch and three-quarters long, obtuse, only a third or fourth part immersed in the cup.

QUERCUS AGRIFOLIA, *Née, in Ann. Sc. Nat.* 3, *p.* 371. Q. oxyadenia, *Torr. in Sitgr. Rep. t.* 17. Q. acutiglandis, *Kellogg, l. c.* Bear cañon of the Sierra Nevada. We have elsewhere remarked how variable are the leaves and acorns of this species. The acorns collected by Mr. Blake were all elongated, and very acute. The plant generally forms low, scrubby bushes, but is sometimes twenty feet high.

QUERCUS DOUGLASII, *Hook. & Arn. Bot. Beech. p.* 371; *Hook. Ic. t.* 382 *and* 383. Summit of Tejon Pass. This belongs to the group that includes Q. alba.

QUERCUS IMBRICARIA, *Michx. Fl.* 2, 197; *Michx. f. Sylv.* 1, *p.* 65, *t.* 15? Tejon Pass; leaves only. Without the fruit we cannot determine the species with certainty, but the leaves so strongly resemble those of the Laurel-oak, that we would have little doubt as to the identification had the Q. imbricaria ever been found before west of the Rocky Mountains. The late Captain Gunnison collected it on the headwaters of the Arkansas.

POPULUS MONOLIFERA, *Ait. Kew. ed.* 1, 3, *p.* 406; *Michx. f. Sylv.* 1, *t.* 96, *fig.* 2. P. Canadensis, *Michx. l. c. t.* 95. This is the common cottonwood, which has a range from the Atlantic to the Great Colorado, and almost as great an extent of latitude. It is abundant in some places near Fort Yuma.

SALIX LONGIFOLIA, *Muhl.*, var.?: foliis dense serratis; fructibus glabris. On the Colorado.

EPHEDRA ANTISIPHILITICA, *Moric.* Mountains east of San Diego.

CYPERUS PHYMATODES, *Muhl. Gram. p.* 23. Abundant in the immediate valley of the Gila, ten miles from Fort Yuma; November. Near Kern River, Tule; August.

CYPERUS MICHAUXIANUS, *Schultes; Torr. Cyp. p.* 259. Banks of the Colorado, in moist places; a dwarf form.

SCIRPUS LACUSTRIS, *Linn.; Torr. Cyp. p.* 321. Kern River; August. The specimens are remarkably tall, being more than eight feet high, but the panicle of spikelets is very small.

VILFA UTILIS (n. sp.): glabra culmis prostratis v. assurgentibus ramosissimis tenuibus; foliis (1″–2″) angustis convolutis confertis patulis v. recurvis; panicula (1″) contracta pauciflora; (spiculis $\frac{2}{3}$‴;) glumis subæqualibus lanceolatis acutis paleas æquales acutiusculas dimidio bre-

voribus. Between the Tejon Pass and the Lost Hills of California. This grass is not uncommon in New Mexico and western Texas, where it is used by the natives for stuffing pads for loaded mules, its soft thread-like culms making it admirably fit for this purpose. Mr. Blake's specimens are nearly two feet long, which is twice its usual length. In the young flowers the glumes are scarcely one-third the length of the paleæ, but at maturity, they are commonly one-half their length. It belongs to a group of the genus that includes V. Virginica, *Linn.* and V. Matrella, *Nees.* It is also nearly related to V. humifusa, *Hook.*, but that has unequal glumes, the upper one nearly as long as the paleæ, or sometimes one-third shorter. No. 958, of Fendler's New Mexican collection, and No. 1983, of Wright's, are the same as the Californian plant, differing only in the more rigid leaves, and somewhat more acute paleæ.

Another, and apparently new, Vilfa was found by Mr. Blake, at the head of Tulare Valley, but his specimens are rather imperfect, and we defer giving it a name for the present. It is an erect grass, about six feet high, simple, with narrow, convolute leaves, and scabrous sheaths. The panicle is two feet long, and much contracted. The spikelets are lanceolate, and nearly terete, scabrous under a lens. Glumes equal, rounded on the back, one-fourth shorter than the lanceolate, rather acute paleæ; the inferior paleæ a little hairy at the base. No. 1993, of Wright's collection, is near this species, but it differs in the glabrous flowers, and the paleæ a little shorter than the glumes, without any hairiness at the base.

Polypogon Monspeliensis, *Desf.* Var. ? monolepis: palea inferiore setam infra apicem exserente glumis duplo longiorem, superiore nulla. Posé Creek, Walker's Pass; August. Culm terete, simple. Leaves flat, and with the sheaths puberulous; ligule oblong. Panicle oblong, dense and spiciform, somewhat interrupted. Glumes equal, acuminate, and cuspidate; serrulate on the keel. Inferior palea scarcely more than half as long as the glumes, 4-toothed at the summit, with an awn arising above the middle of the back nearly twice the length of the glumes; the upper palea wanting, or extremely minute. If the characters here given prove to be constant, this is probably a distinct species from P. Monspeliensis.

Muhlenbergia diffusa, *Schreb. Gram.* 2, *t.* 51. Var. aristis multo longioribus. Tulare Valley. Perhaps a distinct species.

Eriocoma cuspidata, *Nutt. Gen.* 1, *p.* 30. Urachne lanata, *Trin. Act. Petrop.* 1834, *p.* 126. "Grows in bunches, on plains; October." Mr. Blake has not recorded the precise station of this grass, but we have never received it before from any part of California.

Aristida Humboldtiana, *Trin. & Rupr. Stip. p.* 118? Head of Tulare Valley, California; September. Culm apparently tall, glabrous; sheaths smooth, hairy at the throat. Panicle erect, pyramidal, about a foot long, the branches solitary, in pairs, or semiverticillate; the divisions appressed and racemose. Glumes slightly unequal; the lower one about 4 lines long, the upper ½ a line longer, cuspidate. Paleæ a little exceeding the glumes. Lateral setæ as long as the flowers, the central somewhat longer, equally spreading, straight. We are by no means confident that the species is correctly determined.

Bouteluna (Chondrosium) polystachya, *Benth. Bot. Sulph. p.* 56; *Torr. in Emory's Rep. p.* 153. Hill-sides, on the Colorado, and in the desert west. There are usually 4 or 5 spikes, but sometimes only 3. At each joint of the spikes there are two kinds of spikelets; the lower one 1-flowered; the upper sesquiflorous. The rudimentary flower is sometimes reduced to 3 awns, with a tuft of hairs at their common base. (Tab. X.)

Megastachya—near M. conferta (Poa conferta, *Ell.*) Kern River, Tule; August. Culm 2–3 feet high. Leaves narrow, convolute when old, glabrous, as is also the sheath. Panicle

elongated, much contracted, and spiciform. Spikelets 8-10-flowered, 3 lines long, and scarcely half a line wide.

FESTUCA. Kern River. This I have not received before, and it is not described as a North American Festuca. It may, however, be a Chilian species, and I regret not having the means of determining it at present. It is a tall grass, with flat smooth glaucous leaves, and a long contracted panicle. The spikelets are about 10-flowered. Glumes very unequal; the upper one much longer, and abruptly mucronate at the tip. Lower palea hairy on the margin toward the base, bifid at the tip, with a short straight bristle between the teeth. Upper palea much smaller.

PHRAGMITES COMMUNIS, *Linn.* Warm Springs, Cohuillas.

ELYMUS ARENARIUS, *Linn.* Posa creek; August. This occurs also in other parts of California, but is not found on the eastern side of the continent.

PANICUM CRUS-GALLI, *Linn.* Var. Setaria Californica, *Kellogg, in Proceed. Calif. Acad. Nat. Sc. p.* 27? Kern River. This is a very tall form. The panicle consists of numerous approximated appressed branches, forming a dense spiciform inflorescence. The flowers are awnless; the inferior glume short and very broad, with a minute abrupt point. Dr. Kellogg's plant was found at the head of the Sacramento Valley.

PANICUM CAPILLARE, *Linn.* With the last. It agrees with the Eastern grass, and it may be an introduced species in California.

DESCRIPTION OF THE PLATES.

PLATE I. FAGONIA CALIFORNICA, (page 359.)

(A BRANCH OF THE NATURAL SIZE.)

Fig. 1. A flower; moderately enlarged.
Fig. 2. A sepal, side view; more enlarged.
Fig. 3. The same, as seen from the inside, equally magnified.
Fig. 4. A petal; and,
Fig. 5. A stamen; both considerably magnified.
Fig. 6. A capsule; moderately enlarged.

PLATE II. DALEA EMORYI, (page 360.)

(A BRANCH OF THE NATURAL SIZE.)

Figs. 1–3. Leaves, of the natural size.
Fig. 4. A flower; moderately enlarged.
Fig. 5. Calyx of the same, shown separately.
Fig. 6. The corolla laid open; *a*, the banner; *b*, *b*, wing-petals; *c*, *c*, keel-petals.
Fig. 7. Stamineal tube; enlarged.
Fig. 8. Part of one of the stamens; considerably magnified.
Fig. 9. The pistil; moderately enlarged.

PLATE III. CERCIDIUM FLORIDUM, (page 360.)

(A BRANCH OF THE NATURAL SIZE.)

Fig. 1. The corolla, showing the arrangement of the petals; enlarged.
Fig. 2. A flower, from which the petals have been removed; more enlarged.
Fig. 3. A stamen; still more magnified.
Fig. 4. The pistil; equally magnified.
Fig. 5. A legume, of the natural size.

PLATE IV. STROMBOCARPA PUBESCENS, (page 360.)

(A BRANCH OF THE NATURAL SIZE.)

Fig. 1. A flower; moderately enlarged.
Fig. 2. The calyx, shown separately.
Fig. 3. The corolla, laid open; more magnified.
Figs. 4 and 5. Front and back views of a stamen; equally magnified.
Fig. 6. An ovary; equally magnified.
Fig. 7. Longitudinal section of the same.

PLATE V. TRICHOPTILIUM INCISUM, (page 361.)

(AN ENTIRE PLANT OF THE NATURAL SIZE.)

Fig. 1. Involucre and receptacle; moderately enlarged.
Fig. 2. A flower; more enlarged.
Fig. 3. The corolla, removed; equally magnified.
Fig. 4. The same, laid open, and showing the stamens; more magnified.
Fig. 5. A stamen; equally magnified.
Fig. 6. Part of the style and its divisions, showing the stigmatic lines; still more magnified.
Fig. 7. Achenium crowned with its pappus; considerably magnified.
Fig. 8. The five scales of the pappus spread out and magnified.
Fig. 9. One of the scales of the pappus; more highly magnified.
Fig. 10. A portion of the same; highly magnified.
Fig. 11. Longitudinal section of an achenium; and,
Fig. 12. Transverse section of the same; both moderately enlarged.

PLATE VI. EREMIASTRUM BELLIOIDES, (page 361.)

(AN ENTIRE PLANT OF THE NATURAL SIZE.)

Fig. 1. The involucre and receptacle; enlarged.
Fig. 2. A ray-flower; more enlarged.
Fig. 3. A disk-flower; equally magnified.
Fig. 4. Corolla of the same, laid open, showing the stamens.
Fig. 5. A stamen; considerably magnified.
Fig. 6. The style, with its divisions, showing the stigmatic lines; more magnified.
Fig. 7. An achenium, crowned with its pappus; magnified.
Fig. 8. A portion of the pappus, from the same.

PLATE VII. ASCLEPIAS SUBULATA, (page 362.)

(UPPER PART OF THE PLANT, OF THE NATURAL SIZE.)

Fig. 1. One of the hoods of the crown, side view; magnified.
Fig. 2. The same, with one side folded back to show the horn.
Fig. 3. An anther, front view; considerably enlarged.
Fig. 4. The same, seen from the inside.
Fig. 5. A pair of pollen masses; considerably magnified.

PLATE VIII. CHORIZANTHE FIMBRIATA, (page 364.)

(AN ENTIRE PLANT OF THE NATURAL SIZE.)

Fig. 1. An involucre and its solitary flower; magnified.
Fig. 2. The involucre shown separately; equally magnified.
Fig. 3. The same, laid open.
Fig. 4. Perianth; equally magnified.
Fig. 5. The perianth, laid open; more magnified.
Fig. 6. One of the segments of the same.
Fig. 7. Ovary and styles; equally magnified.

PLATE IX. QUERCUS CRASSIPOCULA, (page 365.)
(A BRANCH, OF THE NATURAL SIZE.)

Fig. 1. A leaf from a young shoot.

PLATE X. BOUTELOUA (CHONDROSIUM) POTYSTACHYA, (page 366.)
(AN ENTIRE PLANT, OF THE NATURAL SIZE.)

Fig. 1. A spikelet; magnified.
Fig. 2. The superior glume.
Fig. 3. Inferior palea of the perfect flower; magnified.
Fig. 4. Superior palea of the same; equally magnified.
Fig. 5. Sterile flower; also magnified.
Fig. 6. The achenium, crowned with the persistent styles.

Ackerman Lith. 379 Broadway N.Y.

Ackerman Lith. 379 Broadw.

DALEA EMORYI

CERCIDIUM FLORIDUM

Akerman Lith. 379 Broadway N.Y.

STROMBOCARPA PUBESCENS.

Ackerman Lith 379 Broadway N.Y.

TRICHOPTILIUM INCISUM.

EREMIASTRUM BELLIOIDES

Ackerman Lith. 379 Broadway N. Y.

ASCLEPIAS SUBULATA.

Ackerman Lith. 379 Broadway N.Y.

CHORIZANTHE FIMBRIATA.

QUERCUS CRASSIPOCULA

NOTE.

Article VIII was not received in time for publication with the other portion of this report.

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PART III.

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.
WAR DEPARTMENT.

ROUTES IN CALIFORNIA, TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, EXPLORED BY LIEUT. R. S. WILLIAMSON, CORPS TOPOGRAPHICAL ENGINEERS, IN 1853.

BOTANICAL REPORT:

BY

E. DURAND AND T. C. HILGARD, M. D.

WASHINGTON, D. C.
1855.

DESCRIPTION OF PLANTS COLLECTED UPON THE EXPEDITION.

RANUNCULACEÆ.

CLEMATIS LIGUSTICIFOLIA, *Nutt. in Torr. & Gr. Flora, vol.* 1, *p.* 9 ; *Gray's Pl. Fendl.*, *p.* 3. Posé creek ; August and September.

PAPAVERACEÆ.

ARGEMONE MUNITA, *nova species.* Planta glaucissima, erecta, tenera, aculeis albis retrorsis horrens, circa 2½ pedalis. Folia subamplexicaulia elongato-cordata valde repando-sinuata undulata lobis rotundatis. Flores in apicibus 3–4 conferti, breviter divaricateque pedunculati. Calyx 3-sepalus caducus setosus, quoque sepalo cornuto, cornu in aculeum validum desinente. Corolla 6-petala maxima, 3–4″ diametro ; petalis cuneato-obovatis margine denticulatis albis recte venosis. Germen lanceolato-cylindricum, aculeis rectis dense obtectum. Capsula adhuc ignota.

Stem branching, about 2½ feet high. The whole plant very glaucous and, chiefly on the stems and margins of the leaves, densely covered with strong and slightly retrorse prickles. Leaves subclasping, elongate-cordate, with oblong rounded lobes deeply repando-sinuate and undulate. Flowers in clusters of 3–4 on short divaricate peduncles. Calyx 3-sepalous, prickly, each sepal bearing a horn terminating in a strong prickle. Corolla 3–4″ in diameter; petals six, white, veined, with slightly denticulate margins. Germ lanceolate-cylindrical, densely covered with erect prickles. Capsule unknown.

The specimens submitted to our examination are incomplete, and not sufficiently advanced to determine the shape of the mature capsule and seed. We have compared it with various forms of *A. Mexicana* and with the figure of Lindley's *A. grandiflora* in Bot. Reg. T. 1264. In ours the texture is more delicate than in *A. Mexicana*, and the habitus of the leaves and branches is less acute than in either, being more rounded and undulating ; the peduncles are shorter, stouter, and more divaricate. It grows in large patches at Williamson's Pass, and was in full bloom in August and September.

CRUCIFERÆ.

PACHYPODIUM INTEGRIFOLIUM, *Nutt. in Torr. & Gr.'s Flora, vol.* 1, *p.* 96. Edge of Mohave desert ; September.

STANLEYA INTEGRIFOLIA, *Torr. in Capt. Sitgreaves' Report, T.* 1. Posé creek ; August. Dr. Torrey's *S. integrifolia* differs from James's plant by pedicels much shorter than the stipes ; in the latter, the pedicels are half as long as the stipes.

ZYGOPHYLLACEÆ.

LARREA MEXICANA, *Moric. in Gray's Gen. Ill., vol. 2, T.* 147; L. glutinosa, *Engelm. App. Wisliz., p.* 93. *Zygophyllum tridentatum, D. C.*, 1 *Fl. Mex.* A very common resinous shrub, known in the far west by the name of kreosote plant, on account of its very strong smell. The resin of this shrub, collected by the Pimos Indians, is formed by them into balls which they kick and send before them with their feet, as they journey from one point to the other of their trail.

MALVACEÆ.

SIDALCEA MALVÆFLORA, *Gray's Pl. Wright. part* 1, *p.* 16; S. Neo-Mexicana, *Gray's Pl. Fendl., p.* 23. Sida malvæflora, *Moc. and Sesse.* Posé creek; September.

MALVASTRUM MARRUBIOIDES, *nova species.* Circa bipedalis erecta, tomento stellato albida. Folia petiolata, late-ovata basi truncata vix, triloba, crenato-dentata, subtus reticulato-venosa. Stipulæ lineares. Calycis laciniis ovato-lanceolatis acuminatis. Flores glabri rosei, in paniculis brevibus axillaribus 3–5-floris glomerati ac in spicam terminalem desinentes.

Plant erect, about two feet high, covered with a dense stellate tomentum, of two different sizes, that gives it a pale color and a sandy feel. Leaves petiolate, broadly ovate, truncate at the base, subtrilobate, crenate-dentate, reticulately veined underneath. Stipules linear. Segments of the calyx ovate-lanceolate acuminate. Flowers smooth, rose colored, glomerate in short panicles of 3–5 in the axils of the leaves and merging into a terminal spike. Fort Miller; July.

LEGUMINOSÆ.

HOSACKIA LATHYROIDES, *nova species.* Herba cæspitosa, basi ramosa, caulibus subflexuosis, minute pubescens. Folia imparipinnata, foliolis 5–7 lineari-lanceolatis utrinque acutis. Stipulæ minutæ scariosæ ovatæ acuminatæ. Umbellæ 1–3-floræ, bracteâ lineari-lanceolatâ in parcioribus. Flores subsessiles 5''' longi, flavi, calycis dentibus lineari-acutis.

Herbaceous and cespitose, branching near the base, rather flexuose, minutely pubescent. Leaves imparipinnate; leaflets 5–7 linear-lanceolate, acute at both ends. Stipules rudimentary, membranaceous, ovate acuminate; umbels 1–3-flowered; bract (only on the poorer umbels) linear-lanceolate. Flowers 5''' long, light yellow; teeth of the calyx linear-lanceolate. Resembles somewhat the figure of *Lotus pinnatus*, Hook. in Bot. Mag. T. 2913, than which, however, it has longer and narrower leaves. Fort Miller, on the banks of San Joaquin river; August.

HOSACKIA HEERMANNI, *H. decumbens, var. glabriuscula? Hook. & Arn. in Torr. & Gray's Fl. vol.* 1, *p.* 324. Suffrutex sat regulariter ramulosus, omnino puberulus, 1½–2 pedalis. Ramuli tenues subflexuosi foliosi umbellosi, internodiis foliorum fere longitudine. Folia fere omnia umbellam in axillo gerentia—imparipinnata, foliolis 3–5 alternantibus, rhomboideo-ovatis acutis mucronulatis pubescentibus; stipulis minutis fusiformibus rubicundis lanugine alba celatis. Umbellarum pedunculi rachidis folii fere longitudine, 2–4–6-flori foliolumque solitarium ferentes. Flores subsessiles. Calyx campanulato-tubulosus pubescens, laciniis acutissimis. Corolla parva flava, petalis gracilibus obtusis, apice fusco-purpurascentibus. Legumen pubescens, pendulum, incurvum, rostro subrefracto subulato apice uncinato vixque dimidiâ leguminis longitudine. Semina 1–2. Ab. *H. decumbente* distinguitur formâ ramosiore ac pubescentiâ densiore, foliis mucronulatis, stipulis haud spinosis, umbellarum pedunculis multo brevioribus, flore minori apice purpurascenti leguminibusque ecarinatis.

Suffruticose, pretty regularly branching, softly pubescent throughout, 1½–2 feet high; branchlets leafy and umbellose, subflexuous, with internodes scarcely as long as the leaves. Leaves imparipinnate; leaflets 3–5, rhombic-ovate, acute, mucronulate, mostly alternate. Stipules minute, fusiform, tomentose; umbel stipitate, shorter than the leaf, 2–4–6-flowered, with an oval bract in it. Flowers small, subsessile, yellow with purplish tips. Calyx tubulate-campanulate. Legumen 1–2-seeded, pubescent, pendulous, incurved, with a subulate uncinate and somewhat refracted rostrum. Differs from *H. decumbens* by being more branched and pubescent, by mucronate leaves, stipules not spinose, peduncles of the umbels considerably shorter, smaller flowers with purpurescent tips and by legumes not carinate and mostly one-seeded. Tejon Pass; September.

HOSACKIA PURSHIANA, *Benth., Torr. and Gray's Flora, vol.* 1, *p.* 327. Lotus sericeus, *Pursh.* Trigonella Americana, *Nutt.* A very variable species in its pubescence and in the size of its leaves. Our plant is one of its smallest forms. Posé creek; August.

LUPINUS GRACILIS, *Agardh., in Torr. and Gray's Flora, vol.* 1, *p.* 372. Lupinus microphylla, *Nutt.* Abundant in the vicinity of Benicia; July.

LUPINUS PERENNIS? *Linn.* Too young to determine with certainty. Same locality as above.

ROSACEÆ.

ROSA FRAXINIFOLIA, *Bork., Torr. and Gray's Folia, vol.* 1, *p.* 460. Fort Miller; July.

LYTHRACEÆ.

LYTHRUM ALATUM, *var.* linearifolium, *Gray's Pl. Lindh., part* 2, *p.* 188. Abundant in the bottoms of the Tajon Pass; September.

ONAGRACEÆ.

ZAUSCHNERIA CALIFORNICA, *Presl. in Torr. and Gray's Flora, vol.* 1, *p.* 486. Posé creek; August.

EPILOBIUM COLORATUM, *Muhl. in Torr. and Gray's Flora, vol.* 1, *p.* 489. E. tetragonum, *Pursh.* Posé creek; August.

ŒNOTHERA RHOMBIPETALA? *Nutt. in Torr. and Gray's Flora, vol.* 1, *p.* 493. Our specimens have no leaves, but only foliaceous bracts, at the tip of the branches, a little longer than the capsules; flowers yellow, very large, with rhomboid-ovate petals a little shorter than the style. Tube of the calyx long and slender. A tall and robust plant, very branching, 5–6-feet high, abundant on the bars of streams. Fort Miller; July.

GODETIA (ŒNOTHERA) WILLIAMSONI, nova species. Erecta 1–2 pedalis gracilis sublignosa, epidermide nitido-flavescente; foliis circa pollicaribus albidis lineari-lanceolatis vix runcinatis obtusis basi attenuatis, alternantibus fasciculatisque. Flores in spicis brevibus (et lateralibus) flexuosis 1–1½ pollicares; parte germinali minute hirsuta ovato-lanceolata costata, infundibuli fundo-ciliata, limbi laciniis reliquum calycem vix semipollicarem subaequantibus, petalis obovatis pollicaribus minutissime denticulatis flavis, magna *apice* macula violacea obovata et secus marginem semilunariter decurrente; staminibus alternatim inequalibus, longioribus petalafere æquantibus; stigmate lobis recurvatis ciliatis rubicundis mediam maculam superante. Capsula prismatica albida glabra $\frac{6}{10}$ pollicaris, breviter rostrata utrinque obtusa, costis octo quasi alata, seminibus fuscis prismaticis truncatis apice margine scarioso coronatis.

Slender, 1–2 feet high, with a glossy light-yellowish bark; leaves narrow, somewhat fleshy,

whitish, scarcely runcinate, often fascicled, about an inch long; spikes crowded on short lateral branches; flowers more than 1 inch in length; petals yellow, with a large deeply violet spot on top, obovate and reaching nearly down to the middle of the petals, and with a semi-lunar expansion along the upper margin. Stamens about half the length of the style, and nearly the height of the petals. Capsule light colored, glabrous, prismatic, obtuse at both ends, rostrate, winged with 8 projecting ribs approximated by pairs, seeds chocolate color, prismatic obtuse, with a scarious crown. Fort Miller; July.

Clarkia elegans, *Lindl. in Torr. and Gray's Flora, vol.* 1, *p.* 515. Phœostoma Douglasii, *Spach.* Posé creek; August.

LOASACEÆ.

Mentzelia lævicaulis, *Torr. and Gray's Flora, vol.* 1, *p.* 535. Bartonia lævicaulis, *Dougl.* Fort Miller; July.

UMBELLIFERÆ.

Sium lineare, *Mich. Torr. and Gray's Flora, vol.* 1, *p.* 611. Sium tenuifolium, *Muhl.* S. latifolium, *Darl.* Posé creek; August.

CAPRIFOLIACEÆ.

Sambucus velutina, *nova species.* Frutex 5-6 pedalis, velutino-tomentosus, foliis supra nitidissimis. Foliola 5–7 ovato-lanceolata basi angustiori in lateralibus, obliqua medioque subcordata—acuta, argute-serrulata, dentium apice scarioso, supra nitida et in sicco minute corrugata, nervis parallelis sulcata. Corymbus parvus 4-5 radiatus. Eodem tempore eodemque ramo flores, fructum immaturum maturumque atro-rubentem, gustugrato similique rubi fructui exhibens.

Stem fruticose 5–6 feet high, densely tomentose throughout, excepting the upper surface of the leaves, which is shining and furrowed with the ribs. Folioles 5–7 ovate-lanceolate, finely serrate, coriaceous. Corymb small, 4–5-radiate. Berries deep purple when ripe, agreeable to the taste and almost equal to the black berry. It bears flowers, green and ripe fruit on the same branches. Posé creek; August.

RUBIACEÆ.

Cephalanthus occidentalis, *Linn. Torr. and Gray's Flora, vol.* 2, *p.* 31. Growing on the edge of creeks. Tejon valley; August.

COMPOSITÆ.

Carphephorus junceus, *Benth.* Growing 3–4 feet high in sandy plains and bush. Tejon Pass and Tulare valley; August.

Brickellia Wrightii, *Gray's Pl. Wright. part* 2, *p.* 72. Posé creek; August.

Corethrogyne tomentella, *Torr. and Gray's Flora, vol.* 2, *p.* 99. In some of our specimens with inflorescence much developed, a very striking appearance is produced by the very dense and white tomentum being abruptly replaced by a green glandular and viscous pubescence on the inflorescence. Leaves on the lower part of the branches linear-oblong, appressed and closely sessile; those of the top of the stem broadly obovate obtuse; those of the branches small and bract-like. Tejon valley; September.

GUTTIERREZIA MICROCEPHALA, *Gray, Pl. Fendl. p. 74, ordn.* Brachyris microcephala, *D. C. Prodr. vol. 5, p.* 313. Our specimens being dry and advanced in florition, the heads of flowers, which in the genus *Guttierrezia* are always more or less ovoid, appear loosely turbinate, with straight and very concave scales. Tejon valley; September.

ASTER DURANDII, *Nutt. Gambel's plants.* Posé creek; September.

ASTER CARNEUS, *Nees; Torr. and Gray's Flora, vol. 2, p.* 133. Posé creek; September.

ASTER * * * *aff. punicei.* Too young for study. Scales of the involucre linear subulate, loosely imbricated. Achene compressed, pappus pilose. Fort Miller; July.

ASTER DIVARICATUS, (TRIPOLIUM.) *Nutt. Torr. and Gray's Flora, vol. 2, p.* 163. Posé creek; September.

SOLIDAGO CALIFORNICA, *Nutt. Torr. and Gray's Flora, vol. 2, p.* 203. Posé creek; August.

SOLIDAGO ANGUSTA, *Torr. and Gray's Flora, vol. 2, p.* 204. Tejon valley; September.

LESSINGIA GERMANORUM, *Cham. in D. C. Prodromus, vol. 5, p.* 35. Posé creek; September.

LINOSYRIS CERUMINOSA, (*nova species.*) Erecta 2–3-pedalis, fastigiato-ramosa; ramulis foliisque substantia resinosa spissa ochroleuco-nitentibus. Internodia superiora vix 3–4 lineis longa. Folia linearia subcarnosa puberula, sulco superne longitudinali, dorso rotundata; caulina interdum pollicaria, ramealia 3–6‴ long deorsum incurva. Capitula in apice conferta breviter pedicellata. Squamis involucralibus carinatis, filiformi-mucronatis, flavescentibus.

Stem erect 2–3 feet high, fastigiately branched, with crowded heads on short pedicles, forming a corymb. The whole surface of the stalks is covered with a short, apparently dense, tomentum, infiltrated with a yellowish resinous substance, giving it a texture of ear-wax of a greenish-golden hue. Internodes of the branchlets 3–4 lines. Leaves linear, puberulent, subcarnose, rounded on the back, with a furrow on the upper surface, about one inch long on the stem, half an inch or less, and recurved on the branches. Scales of the involucre carinate, light yellow, darkening towards the filiform mucro. Tejon Pass; September.

LINOSYRIS TERETIFOLIA, (*nova species.*) Fruticulus 8–12 pollicaris corymbosus, ericæ facie, resinoso-vernicatus, balsamum canadense redolens, cumuliformis fruticeta que vasta sistens. Trunculi emarcido-grisei, ramulis ochraceis punctatis, internodiis brevibus, naviculato-depressis, marginatis, filiformibus dense foliosis. Folia ½–1-pollicaria filiforme-teretia obtusa, superne pauxillum sulcata, æque ac ramuli, fusco-viridia et epidermide maxime viscido-resinosa induta. Capitula flava in summo spiculata subsessilia, squamis involucralibus obtusis apice glanduloso-gibbo.

A small shrub, strongly varnished and smelling of fir balsam, covering extensive tracts of land, like the common heath of Europe, and presenting a corymbose summit darkly-green with filiform, erect, dotted and scabrous leaves and branches, both alike, with crowded yellow heads of flowers. The lower branches have a grey and mealy, the upper a bright ochre-yellow dotted rind, with the internodes navicularly depressed and costately bordering ridges. Leaves obtuse, 1–1½ line long. Heads of flowers subsessile, aggregated into dense terminal spikelets and clusters, forming a corymb. All over the mountains around Tejon valley; September.

APLOPAPPUS MENZIESII, *Torr. and Gray's Flora, vol. 2, p.* 242. Tejon Pass; September.

BACCHARIS CŒRULASCENS, *D. C. Prodr., vol. 5, p.* 402. A shrub from 6–10 feet high, resembling a willow, and growing on the edge of streams. Posé creek and Tejon Pass; September.

PLUCHEA FŒTIDA, *D. C. Torr. and Gray's Flora, vol. 2, p.* 261. Baccharis fœtida, *Linn.;* Conyza camphorata, *Pursh.* Tejon Pass; September.

XANTHIUM STRUMARIUM, *Linn.; Torr. and Gray's Flora, vol. 2, p.* 294. Posé creek; August.

Helianthus petiolaris, *Nutt. Torr. and Gray's Flora, vol.* 2, *p.* 319. Posé creek; August.

Helianthus doronicoides? A glaucous variety, with striate purple stems, from 6–10 feet high. Tejon valley; September.

Hemizonia angustifolia, *D. C. Torr. and Gray's Flora, vol.* 2, *p.* 398. Fort Miller; July.

Hemizonia pungens, *Torr. and Gray's Flora, vol.* 2, *p.* 399. In flower and fruit. Posé creek; August and September.

Hemizonia macradenia, *D. C. Torr. and Gray's Flora, vol.* 2, *p.* 400. Tejon valley; September.

Artemisia dracunculoides, *Pursh. Torr. and Gray's Flora, vol.* 2, *p.* 416. Abundant in the Tejon valley and all over the country; August and September.

Artemisia Douglasii, *Bess. Torr. and Gray's Flora, vol.* 2, *p.* 420. With the above; also very common.

Gnaphalium Sprengelii, *Hook and Arn.; Torr. and Gray's Flora, vol.* 2, *p.* 447. G. luteo-album, *Var.;* occidentalis, *Nutt.* Posé creek; August.

Senecio longilobus, *Var. glabrescens, Gray, Pl. Wright, No.* 399. Posé creek; August.

Stephanomeria paniculata, *Nutt. in Torr. and Gray's Flora, vol.* 2, *p.* 473. Tall and branching; growing in large patches. King's river; July.

OLEACEÆ.

Fraxinus juglandifolia, *Var. integrifolia, Lam. in D. C. Prodr., vol.* 8, *p.* 278. Fraxinus viridis, *Mich.* A large spreading tree on the edge of streams. Posé creek; August.

APOCYNEÆ.

Apocynum cannabinum, *Var. lanceolatum, nova varietas.* Leaves lanceolate, acute at both ends; very glabrous. River bottoms, Posé creek; August.

ASCLEPIADEÆ.

Asclepias macrophylla, *Nutt. Var. comosa, nova varietas.* Tota planta, exceptis pedunculis, pedicellis umbellarumque involucellis pubescentibus, glaberrima glauca. Caulis gracilis bipedalis subflexuosus erectus, internodiis aliquoties bipollicaribus. Folia spithamæa, ad primum quemque nodum opposita, cetærum ternatim verticillata, in sicco conduplicata, marginibus haud revolutis. Ramuli singuli vel bini in verticellis exiles, dense foliosi. Umbellæ binæ vel trinæ in verticillis supremis, pedunculis sesquipollicaribus, involucris lineari bracteatis, floribus parvis, numerosis, (usque ad quadraginta,) mediam folii partem vix æquantes. Pedicelli dimidia pedunculorum longitudine. Flores virescentes, albido marginati nec fusci. Corollæ lobi ovato-lanceolati concavi, resurgentes margine albo. Coronæ stamineæ stipes eadem ac loborum longitudine; lobi producti, breves obtusi, processibus cultriformibus, cristas connectivorum albo scariosas æquantibus.

Stem erect, slender, rather flexuose, about 2 feet high; leaves a span long, linear, smooth, doubled up without revolute margins, in whorls of three, except at the lowest node of each shoot, where they are opposite—internodes 2″ or more long, each with one or more slim and densely-leaved branchlets, giving it a comose appearance. Umbels 2–3 in each of the upper whorls, scarcely half the length of the leaf, with pedicels half the length of the peduncles, and, together with the involucral bracts, somewhat tomentose. Stipe of the staminal crown, about the length of its lobes, claws cultriform, erect, as high as the white tips of the connectives. Perhaps a new species?

It differs from Nuttall's description of *A. macrophylla*, in Gambel's Plants, by its tomentose pedicels, leaves more approximated, denser umbels, and the absence of brown color in its flowers. Grows abundantly in river bottoms. Posé creek; August.

GENTIANÆ.

ERYTHRÆA TRICANTHA, *Griseb. in D. C. Prodr., vol.* 9, *p.* 60, (*nova var.*) Our plant is intermediary between *E. tricantha and E. Muhlenbergii*, all, probably, being varieties of one species. A very showy and beautiful little plant. Fort Miller; July.

POLEMONIACEÆ.

GILIA ELONGATA? *Stend. in D. C. Prod., vol.* 9, *p.* 30. Our plant differs from D. C.'s description by being scarcely puberulent, although the capitula are densely lanate, by having mostly four segments on each side of the leaves, and by the tube of the corolla being much exserted. Tulare valley; August.

CONVOLVULACEÆ.

CUSCUTA SUBINCLUSA, (*nova species.*) Flores dense glomerati subsessiles. Calyx subovatus, lobis late ovatis obtusis imbricatis. Corolla primodum tubo cylindrico limbo, patente; deinde germine aucto fauceque marcescente contracta, sublageniformis; segmenta ovata, latiora supra basim, dimidia tubi longitudine. Antheræ elongatæ, infra angulis subsessiles, semi-inclusæ. Filamenta antheris breviora. Squamellæ marginibus parallelis maxime ad apicem fimbriatis, conniventes. Germen biapiculato-globosum, bistyle. Styli duplo fere germine longiores, tubi longitudine, subinæquales, stigmata capitata.

Flowers subsessile in dense clusters. Calyx subovate, with broadly oval-obtuse and imbricated lobes. Tube of the corolla cylindrical and afterwards rather lageniform by the increase of the germ and shrinking of the fauces. Lobes of the limb ovate, broadest above the base, half the length of the tube. Anthers subsessile under the dividing angles, half included. Filaments shorter than the anthers. Scales parallel-sided, fringed chiefly on the top, connivent. Germ globose, bi-apiculate with two styles about double the length of the germ, rather unequal; stigmas capitate. On a willow. Tejon Pass; September.

CUSCUTA . . . . . Probably the same as the above, but of smaller size, (for want of nourishment?) and past full florition. Grows on *Artemesia dracunculoides*, same locality.

BORAGINEÆ.

HELIOTROPIUM CURASSAVICUM, *Linn. in D. C. Prodr., vol.* 9, *p.* 558. Muddy localities, Tejon valley; August.

SCROPHULARIACEÆ.

ANTIRRHINUM CORNUTUM, *Benth. Pl. Hartw., p.* 328. Posé creek; August.

ANTIRRHINUM COULTERIANUM, *Benth. Var. appendiculatum*, (*nova var.*) Differs from the description in D. C. Prodr., vol. 9, p. 529, by the shortness of the peduncles; stem simple, erect, glanduloso-pubescent, violet-colored below; leaves on short petioles, ovate lanceolate, smooth; many sterile setiform branches, bracteate at top, springing from the axils; flowers in a subsecund raceme, almost subsessile. Calyx and corolla strongly pubescent, upper segment of the calyx broadly lanceolate, the rest linear lanceolate. Perhaps a new species. Posé creek; August.

PENTSTEMON HETEROPHYLLUS, *Lindl. in Bot. Reg. T.* 1899; *D. C. Prodr., vol. X, p.* 330. Tejon Pass, on mountain sides; September.

MIMULUS CARDINALIS, *Dougl. in D. C. Prodr., vol. X, p.* 370; *Curt. Bot. Mag. T.* 3560. Along streams, Fort Miller and Tejon Pass; August.

MIMULUS SCOULERI, *Hook. Fl. Bor. Am., vol. II, p.* 100. Might be referred to *M. luteus*, of which it seems to be but a small form. Posé creek; August.

MIMULUS EXILIS, *nova species.*—Herba circa pedalis erecta gracillima, ad apicem vix paulum ramosa, exsucca, sparse villosa. Caulis teres, jam prope basim et abinde flores singulos vel oppositos pedunculis setiformibus foliaque superantibus prodens. Internodia 1–1½″ longa. Folia opposita sessilia elliptico-lanceolata, ¾″ longa. Calyx inflato–campanulatus subangulatus (?) oblique quinquefidus, segmentis acutis, inferioribus majoribus latioribusque, demum magis inflatus. Corolla 4‴ longa, flava, limbo parvo, fauce pilosa maculata. Stamina inclusa. Capsula membranacea ovato-lanceolata subacuminata, calycem demum æquans. Semina parva ovata, testa granulata. Herba habitu a reliquo genere *Mimulo* satis diversa. Forsan subgenus vel genus novum (Cerastodium?) instituendum.

A slender erect herb, sparsely villous, a foot or more high, not succulent. Stem terete, filiform, a little branched near the top. Internodes one to nearly two inches long. Leaves sessile, elliptico-lanceolate. Peduncles setiform, longer than the leaves. Calyx oblique, subangular (?) deeply fivecleft, at first campanulate, and finally inflated. Corolla 4‴ long, yellow, limb small, fauces pilose, spotted. Stamens included. Capsules membranaceous, ovate-lanceolate pointed, finally equalling the calyx, ¼″ long; seeds small, ovate, testa granulate. Habitus rather different from that of the genus *Mimulus*. Posé creek, August.

CASTILLEJA CANDENS, *nova species.*—Herba circa pedalis erecta, nonnunquam ramosa, basi glabra, supra cinereo-pubescens, bracteis calycibusque omnino rubentibus, basibus obscuris, apicibus fulgentibus; corollis glaberrimis, maxime exsertis, pallide atroflavis cunctisque nigricante venosis. Folia circa pollicaria, inferiora integra, linearia, acuta; cætera profunde tripartita, trinervia, segmentis linearibus; floralia latiora, apicibus acuminato-lacinulatis. Calyx 1¼–1½″, subinflatus bifidus, lobis lanceolato-bidentatis. Corolla fere bipollicaris striata, labio superiori sæpe pollicari, inferiori rudimentario.

Herbaceous, erect, about a foot high, and, except towards the base, grayish puberulent; less so on the lower surface of the leaves. Leaves 1″ or more long, and, as well as their segments, linear, the lower ones entire, acute; all others tripartite, trinerved; those of the inflorescence broader and acuminately lacinulate at their apex; the upper, as well as the calyx, entirely red and darkly veined, dusky at the base, scarlet at the top. Calyx 1¼ to 1½″ long, subinflated, bifid, each lobe lanceolately bidentate. Corolla 2″ long, smooth, of light fuscous yellow, with black veins; the lower lip rudimentary, the upper often 1″ long. In river bottoms, Posé creek; August.

CORDYLANTHUS FILIFOLIUS, *Nutt. in D. C. Prodr., vol. X, p.* 597; *Adenostegia rigida, Benth.* Posé creek; August.

LABIATÆ.

POGOGYNE DOUGLASII, *Benth. in D. C. Prodr., vol. XII, p.* 243. Fort Miller; July.

TRICHOSTEMA LANCEOLATUM, *Benth. Lab. in D. C. Prodr., vol. XII, p.* 573. A remarkably fragrant plant. Fort Miller; July.

SOLANACEÆ.

Solanum pterocaulum, *Dunal in D. C. Prodr., vol. XIII, sect.* 1, *p.* 52. Posé creek; July.

Solanum Californicum? *Dunal in D. C. Prodr., vol. XIII, sec.* 1, *p.* 86. A spreading plant not over a foot high, with purplish black berries and large light purple flowers. Fort Miller; July.

Datura metel, *Linn. in D. C. Prodr., vol. XIII, sec.* 1, *p.* 543. Abundant at Fort Miller and upwards; July.

SALSOLACEÆ.

Obione occidentalis, *Moq. in D. C. Prodr., vol. XIII, sec* 11, *p.* 112. Side hills, abundant in southern California; August.

Obione Barclayana? *Benth. in D. C. Prodr., vol. XIII, sec.* 11, *p.* 112. Differs by the petioles being 1–3‴ long. We have only the male flowers. Growing in bushes, rounded in their forms, about six feet high. Branches numerous, forming a thick and dense mass. Posé creek; August.

Obione bracteosa, *nova species.* Planta herbacea, 2–3-pedalis, oleracea farinoso-lepidota, monoica. Rami sulcati, apicibus masculiferis paniculatis; parte inferiori foliosa et singulis axillis spicam fœmineam bracteosam prodentes. Internodia ½″ vel minora. Folia fusco-viridia glauca membranacea, sessilia, lanceolata acuminata mucronata, passim dentata vel integra, pollicaria vel minora, superne minus lepidota. Florum masculorum glomeruli globosi, in spicas laxiores, paniculum ebracteatum terminalem constituentes, dispositi. Flores fœminei in bractearum axillis glomerati; bracteæ attenuatæ, maxime acutatæ, albido-lepidotæ. Thecæ immaturæ 1‴ longæ, subgloboso-lenticulares, reticulatæ, cristis foliaceis muricatæ, alatæ acuteque apicatæ.

An herbaceous monœcious plant, 2–3 feet high, with furrowed branches about a foot or more long. The top nearly destitute of leaves, branching into a panicle composed of simple interrupted spikes of globosely-glomerate male flowers, and the lower part bearing in the axil of each leaf a bracteose spike of female flowers. Internodes ½″ or less. Leaves oleraceous, sessile, lanceolate acuminate, mucronate, sparsely dentate or entire, 1″ or less long, darkish, rather glaucous, less lepidote on the upper surface. Female spikes crowded with attenuated and strongly pointed whitish lepidote bracts. The immature thecæ orbicularly subglobose, reticulated, winged, muricated, and acutely tipped with jagged leafy crests. Growing in large bushes in bottom lands. Posé creek; August.

POLYGONACEÆ.

Eriogonum angulosum, *Benth. in D. C. Prodr., vol. XIV, now in press; E. Simpsoni, Torr. ined.* About a foot high, very tomontose. Leaves, above the baseal whorl, by twos, besides the clasping reflexed and very brittle bracts that in the number of 3 are present at each node throughout the genus. Pedicels smooth, setiform, unilateral. Involucre turbinate. Paleolæ obovate spathulate, very woolly, verdant or brownish at their exserted tips. Flowers small, numerous, whitish or light flesh-colored. We have two states of inflorescence different in appearance. Posé creek; September, on the margin of streams.

Eriogonum fasciculatum, *Nutt?* A low, stoutish, and much branched shrub, with a brown tattered bark on the lowest branches. Leaves elliptic oblong, fasciculate and slightly revolute.

Umbels compound on long peduncles. Flowers numerous, showy, whitish with red central lines. Posé creek ; September.

ERIOGONUM ROSEUM, *nova species.* Herba sesquipedalis erecta virgato-ramosa arachnoideo-tomentosa, bracteis trinis parvis appressis ovato-acutis fusco-rubentibus, basi foliosa, dein scapiformis multumque infra medium in bractearum axillis trifurcata, verticillo unico trifoliato, nunc ramulos ac folia prodente, cum brachiis alternante, nonnunquam capitulis imæ furcæ insidentibus; abinde solum ad nodos ramiferos foliis singulis parvis. Folia anguste spathulato-ovata, margine undulata, in petiolum longum attenuata, superne rubentia, radicalia cum pedicellis 1½–2″ longa. Involucra sessilia plerumque solitaria, tubuloso-campanulata compressa secundum ramos subsecunda, nonnunquam et terminalia. Flores parvi exserti incarnati vel purpurei. Paleolæ capillares inclusæ.

The whole plant, except the flower, covered with a white arachnoid tomentum. Stem about 1½ foot high, virgately branched, with a whorl of three bracts at each node, (besides occasional leaves,) leafy at the base, hence scapiform and trifurcate below the middle, with the prongs opposite at the bracts, and alternate to a solitary ternate whorl of leaves, which sometimes produce accessory branches and leaves from their axils, and sometimes capitula seated in the very centre of the trifurcation ; a small solitary leaf at each further branching. Leaves narrowly spathulate-obovate, undulate at the margin, attenuate into long petioles, with a reddish tinge; radical leaves 1½—2 lines long, including the petiole. Involucres sessile, mostly solitary, tubuloso-campanulate, acheniform, unilateral along the branches and terminal. Flowers small, glabrous, exserted, pinkish or purpurascent. Floral chaff capillary included. Posé creek; September.

ERIOGONUM PLUMATELLA, *nova species.* (Specimina incompleta.) Caulis vix pedalis, dense floccoso-tomentosus, rami divaricati, spiculis densis (cum internodiis vix 3-linearibus) pinnati. Folia * * * * * Bracteæ trinæ, patentes in spicis triangulares, in ramis oblongo-lineares, obtusæ. Involucra solitaria, campanulata, segmentis rotundatis, incarnato-fusca. Flores albi, lobis obovatis. Paleæ pallidæ, lineari-lanceolatæ vel truncatæ, apice denticulatæ, pube longa sparsa exserta.

(Specimens incomplete.) Stem hardly a foot high, densely tomentose, terminating in divaricate panicles, pinnate with crowded spikelets, internodes scarcely 3 lines long. Leaves, (apparently all radical.) Bracts in threes spreading, those of the spikelets triangular, those of the branches oblong linear obtuse. Involucres solitary, campanulate, with rounded segments, and of a reddish-brown color. Flower white, with ovate lobes. Paleolæ linear lanceolate truncate, denticulate at tip with a sparse, but exserted pubescence. Posé creek; September.

ERIOGONUM HEERMANNI, (*E. geniculatum Journ. Acad. Phil., vol.* 3, *part* 1,) *nova species.* (Specimina incompleta.) Caulis circiter pedalis, (æque ac involucra,) pallide virens glaberrimusque, ramis divaricatissime furcatis. Folia. * * * * * Bracteæ trinæ minutæ late triangulares, patentes. Involucra solitaria, parva, campanulato-subglobosa. Flores magni involucris duplo longiores, pallide incarnati, lobis exterioribus orbiculato-obcordatis interioribus obovato-linearibus acutis. Paleolæ lineares lanceolatæ cuneatæ, apice rubente truncato denticulato, involucrum æquantes, pube glandulosa.

Stem about a foot high, and, as well as the involucres, pale green and very glabrous; branches very divaricately forked. Leaves * * * * * (apparently only radical.) Bracts in threes, minute, broadly triangular, spreading. Involucres solitary, small, campanulate,

subglobose. Flowers large, twice the length of the involucre, flesh-colored, external lobes orbicular-obcordate, the others obovate-linear and acute. Paleolæ glanduloso-pubescent, slender, with more or less truncate denticulate red tips equalling the involucre. Same locality as the above.

Eriogonum nudicaule? *Torr. ined.* Tejon valley; September.

Eriogonum nudum, *Dougl. in Hook Fl. Bor. Amer., vol. 2, p.* 135. Posé creek; September.

Eriogonum inflatum, *Torr. in Fremont's 2d report.* Tejon valley; August.

EUPHORBIACEÆ.

Euphorbia ocellata, *nova species.* Herba cæspitosa depresso-ascendens glabra, fronde complanata, nodis tumentibus. Folia opposita oblique arcuateque cordato-ovata unaque cum petiolis plus minus 3 lin. longa, tertiam fere internodiorum partem æquantia, costa mediana superne sulcata inferne in nervum producta. Stipulæ filiformes. Involucra circa 1 lin. longa, pedicellis longiora ovoidea quinque-costata, quinque-dentata, dentibus laciniatis ochroleucis et alternantibus cum totidem glandulis margine annulari apothecia simulantibus, plerumque ochroleucis sed in capitulis junioribus nonnunquam purpureis. Capsulæ haud carinatæ.

Stem cespitose, depressed, ascending, glabrous; foliage flat and two-ranked, nodes enlarged. Leaves opposite, about 3 lines long including the very short petiole, scarcely one-third the length of the internodes, the exterior half of the leaf obliquely ovate, the other half acuminately-cordate. The middle rib arched, furrowed on the upper surface and prominent on the back. Stipules filiform. Involucre ovoid, 5-ribbed, about 1 line long, with shorter pedicels. Segments 5, with laciniate ochroleucous tips alternating with as many stipitate flat glands, with an annular margin, and resembling an *apothecium*, generally ochroleucous, but sometimes purple in the younger involucres. Capsules not carinate. Posé creek; August.

Eremocarpus setigerus, *Benth.* *Croton setigerum. Hook.* Fl. Bor. Amer. Vol. 2, p. 114. Posé creek; August.

CYPERACEÆ.

Cyperus. * * * * * Several forms, apparently of the same species, scarcely sufficiently advanced. Posé creek and Tulare valley; August.

GRAMINEÆ.

Leptochloa fascicularis, *Smooth.* *Festuca fascicularis, Mich.* Posé creek; August.

Bryzopyrum Douglasii, *Hook.* Posé creek; September.

Eragrostis * * * * * Tulare valley; September.

Elymus * * * * * Leaves rigid, glaucous, so completely revolute as to appear tubular, subulate subspinescent. Sheaths striate glabrous. Spikes elongated, slender, erect, subinterrupted. Spikelets few flowered smoothish. Paleæ with short and stiff awns. Tulare valley; September.

Phragmites communis, *Triun.* *Arundo phragmites, Linn.* The grass from which the Indians extract their sugar. Tejon valley; September.

Panicum capillare, *Linn.* Two states of inflorescence, one young, the other far advanced with divaricately branching panicles, nearly $1\frac{1}{2}$ foot long. Posé creek; August and September.

Panicum crus-galli, *Linn.* Tulare valley; September.

E. DURAND.
T. C. HILGARD, *M. D.*

Philadelphia, 1854.

Ackerman Lith

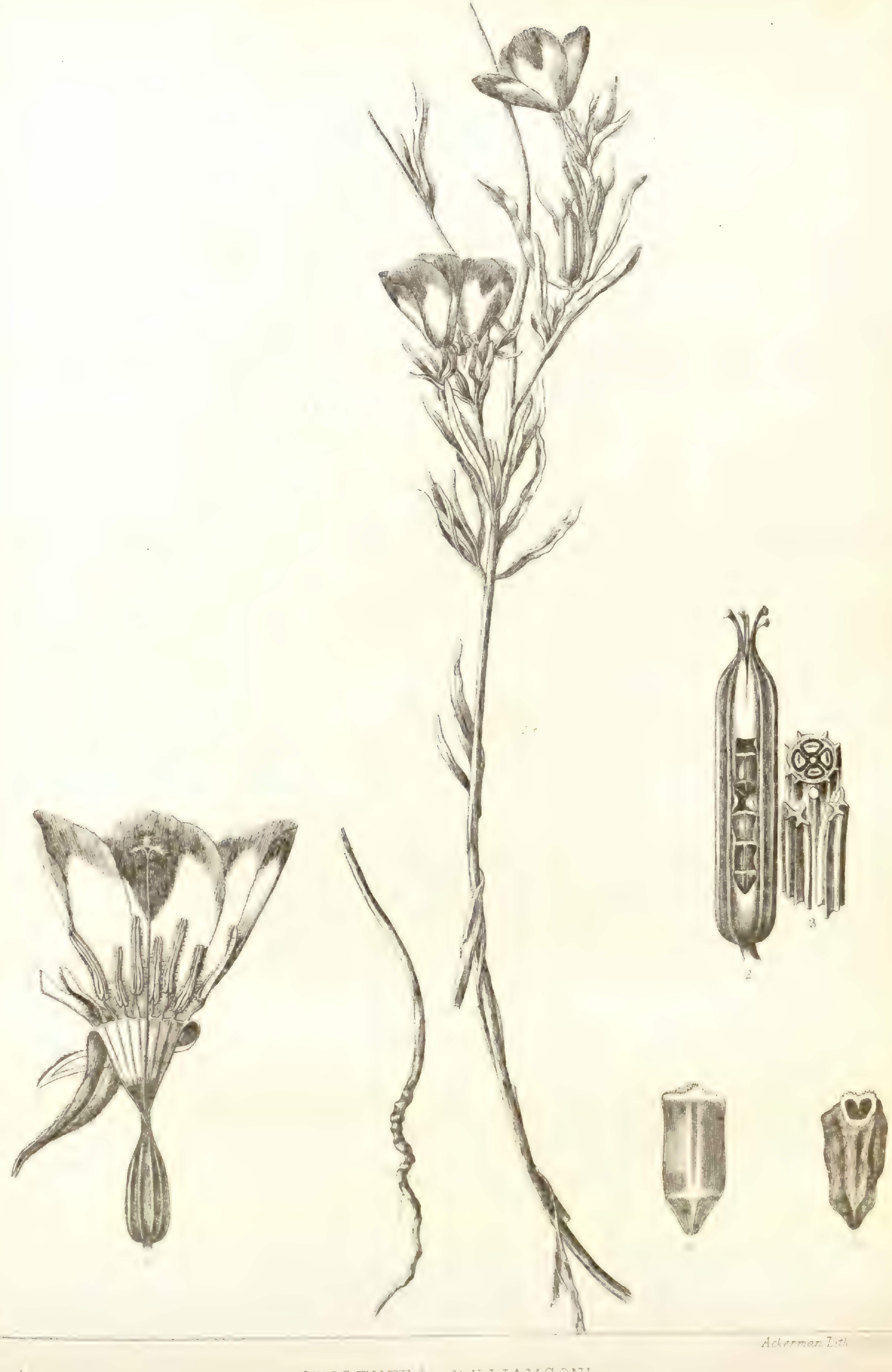
ARGEMONE MUNITA

A. [illegible] Lith. 379 Broadway N.Y.

MALVASTRUM · MARRUBIOIDES.

HOSACKIA LATHYROIDES.

Ackerman Lith.



Ackerman Lith.

ŒNOTHERA WILLIAMSONI

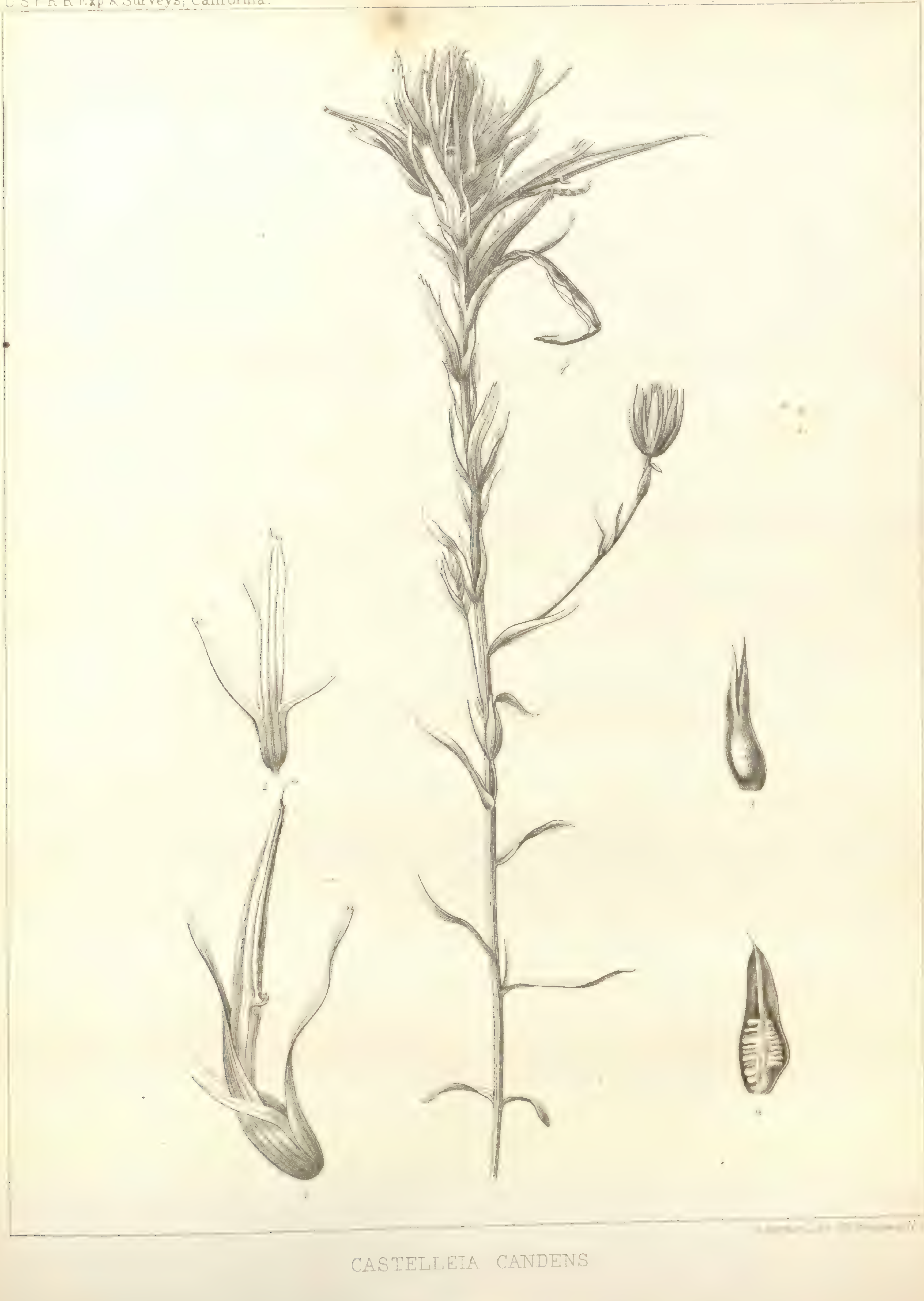
LINOSYRIS TERETIFOLIA

1
2
3

ANTIRRHINUM CORNUTUM.

Ackerman, Lith. 37 Br.

ANTIRRHINUM [illegible]



CASTELLEIA CANDENS

ERIOGONUM ROSEUM

ERIOGONUM PLUMATELLA

ERIOGONUM HEERMANNI

Ackerman Lith.

PART IV.

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

ROUTES IN CALIFORNIA, TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, EXPLORED BY LIEUT. R. S. WILLIAMSON, CORPS TOPOGRAPHICAL ENGINEERS, IN 1853.

ZOOLOGICAL REPORT.

WASHINGTON, D. C.
1857.

NOTE.

The Zoological Report will appear in a subsequent volume, it being found impossible to prepare it in time for publication in connexion with the other parts of this report.

APPENDICES.

APPENDIX A.

DISTANCES AND ALTITUDES.

FROM MARTINEZ TO THE WAGON ROAD LEADING TO THE MOUTH OF THE GILA.

Prominent points and remarks.	Intermediate distances.	Total distance from Martinez.	Altitude.
Martinez, on the straits of Carquines, opposite Benicia.			
Livermore's rancho	40. 42	40. 42	
Entrance of Livermore's Pass	3. 84	44. 26	481
Summit of Livermore's Pass	3. 44	47. 70	686
Elk Horn, at eastern base of Livermore's Pass. The distance from summit is by the wagon road, and circuitous	6. 90	54. 60	89
Grayson, a ferry on the San Joaquin river	27. 54	82. 14	
Davis' ferry, Tuolumne river	28. 85	110. 99	
Merced river	18. 87	129. 86	
Bear creek	18. 33	148. 19	
Mariposa river	6. 03	154. 22	
Chowchilla river, sometimes known as the Big Mariposa	10. 39	164. 61	
Fresno river	12. 15	176. 76	
Cotton-wood creek	7. 72	184. 48	
Fort Miller, on San Joaquin river, in foot-hills of the Sierra Nevada	9. 40	193. 88	402
Slough of King's river	25. 73	219. 61	
Pool's ferry, King's river	12. 32	231. 93	
Crossing of St John's creek. This is the first of four streams crossed by the wagon road, into which the Pi-pi-yu-na divides itself after emerging from the Sierra. These streams are commonly known as the Four Creeks	28. 13	260. 06	
Kah-wee-ya river, the second and principal one of the Four Creeks	. 89	260. 95	
Cameron creek, the third of the Four Creeks	3. 33	264. 28	
Deep creek, the fourth of the Four Creeks	. 29	264. 57	
Tule river	22. 08	286. 65	
Moore's creek	5. 08	291. 73	
White creek	14. 91	306. 64	
Depot camp, on O-co-ya, or Pose creek	24. 35	330. 99	738
Po-sun-co-la, or Kern river, at the crossing	10. 87	341. 86	
Depot camp in the Tejon	31. 08	372. 94	1447
Summit of the Tejon Pass	13. 12	386. 06	5364
Eastern base of Sierra Nevada	6. 71	392. 77	3483
Summit of coast range in San Francisquito Pass	18. 00	410. 77	3437
Southeast fork of Santa Clara river	15. 85	426. 62	
Entrance to San Fernando Pass	3. 60	430. 22	1286
Summit of San Fernando Pass	3. 90	434. 12	1940
Mission of San Fernando	5. 90	440. 02	1048
Cahuenga rancho, at crossing of a branch of Los Angeles river	10. 75	450. 77	
Los Angeles	10. 21	460. 98	
Mission of San Gabriel	9. 00	469. 98	
Crossing of San Gabriel river	6. 79	476. 77	
Qui-qual-mun-go rancho	26. 64	503. 41	
Sycamore Grove	14. 00	517. 41	1982
San Bernardino, Mormon settlement	17. 69	535. 10	1118
Summit of San Gorgonio Pass	27. 10	562. 20	2808
Eastern base of San Gorgonio Pass	18. 29	580. 49	
Hot Spring	7. 36	587. 85	572
Deep Well	10. 62	598. 47	160
Cohuilla village	15. 82	614. 29	85
Water in desert below point of rocks	12. 60	626. 89	
Salt creek, a very circuitous route	28. 94	655. 83	—70
Point where the party struck the wagon road leading from the mouth of the Gila to San Diego	17. 62	673. 45	312

APPENDIX A—Continued.

FROM SAN DIEGO TO FORT YUMA.

Prominent points and remarks.	Intermediate distances.	Total distance from San Diego.	Altitude.
Mission of San Diego.			
San Pasqual	29. 09	29. 09	
Rancho of Santa Isabel, formerly a mission	23. 49	52. 58	
Warner's rancho, near Agua Caliente	11. 18	63. 76	2911
Summit of Warner's Pass, Coast range	5. 10	68. 86	3780
San Felipe, Indian village	10. 18	79. 04	2176
Summit of divide between San Felipe and Carrizo creek	9. 22	88. 26	
Vallecito, Indian village	9. 19	97. 45	
Last Water in Carrizo creek	18. 57	116. 02	431
Point where the party coming from San Gorgonio Pass struck the wagon road	11. 00	127. 02	312
Big Laguna	12. 92	139. 94	—70
Little Laguna	10. 29	150. 23	
Alamo Mocho	14. 16	164. 39	—70
Cook's Wells	21. 11	185. 50	62
Algodones	11. 18	196. 68	46
Pilot Knob—camp	5. 06	201. 74	115
Fort Yuma, 75 feet above the river	6. 51	208. 25	108

APPENDIX B.

LATITUDES AND LONGITUDES.

Date.		Localities.	Latitude, North.	Longitude, West.
1854.			° ′ ″	° ′ ″
		Benicia (barracks)	38 03 21	122 07 13
July	15	Livermore's rancho	37 44 30	121 45 50
	25	Fort Miller	37 00 08	119 40 13
Aug.	6	Pose Creek, Depot camp	35 30 27	118 53 02
	11	Noon halt, August 11	35 38 18	
	12	Camp near Walker's Pass	35 39 20	
	14	Noon halt, August 14	35 37 17	
	15	Hum-pah-ya-mup creek	35 33 38	
	16	Camp of August 16	35 19 47	
	17	Noon halt, August 17	35 12 04	
	18	Camp in Tah-ee-chay-pah Pass	35 07 28	
	22	In Cañada de las Uvas, August 22	34 54 40	
	25	Camp near Ridley's rancheria	35 02 49	
	27	Noon halt, August 27	34 52 33	
Sept.	4	Tejon Depot camp	35 02 47	118 43 31
Oct.	16	Cow Spring camp	34 34 20	
	22	Mohave Depot camp	34 34 23	117 21 17
Nov.	9	Camp of November 9, Mohave river	34 53 42	
	10	Camp of November 10.......do	34 56 46	
	11	Camp of November 11 and 13, Mohave river	35 03 34	
	17	Camp of November 18..............do	34 56 28	
	20	Camp of November 20..............do	34 41 21	
	21	Camp of November 21	34 19 28	
	24	Jurupa	33 59 28	
	30	Agua Caliente	33 16 38.5	

APPENDIX C.

DATA FOR PROFILES.

WALKER'S PASS.

Station.	Hour.	Date.	At station. Barometer.	At station. Ther. attached.	At station. Ther. detached.	At Pose creek depot camp. Barometer.	At Pose creek depot camp. Ther. attached.	At Pose creek depot camp. Ther. detached.	Height of station in feet. Above mean tide.	Height of station in feet. Previous station.	Distance in miles from— Previous station.	Distance in miles from— Station 1.	Grade per mile from last station.	Remarks.
		1853.		°	°		°	°						
1	12 m	Aug. 11	27.432	83.5	82	29.204	88	88	2558	....	......	....	......	Astronomical station on Kern river.
2	6 p. m..	11	27.314	76	75	29.179	80	80	2632	74	5.75	5.75	13	Camp.
3	10 a. m..	14	27.255	80	80	29.283	85	85	2815	183	6.28	12.03	29	
4	10 a. m..	12	27.159	78	78	29.276	83	33	2902	87	5.06	17.09	17	
5	9 p. m..	12	25.463	63	62.5	29.180	63	63	4551 }					
5	Sunrise..	13	25.447	50	50	29.220	48	48	4505 }					
5	4 p. m..	13	25.500	90	89	29.248	98	98	4798 }					
5	5 a. m..	14	25.468	53	53	29.198	49	49	4483 }	1753	6.44	23.53	272	Camp near Walker's Pass.
6	8 a. m..	13	24.954	76	69	25.478	50	50	5306 }	....	......	....	......	Summit.
6	3 p. m..	13	24.950	90	86	25.500	90	89	5298 }	647	1.51	25.04	428	Lower barometer at camp; upper barometer at station 6.
7	8 a. m..	13	26.940	99	97	24.768	78	69	3143 }	....	......	....	......	Plain southeast of summit.
7	3 p. m..	13	26.940	99	97	24.950	90	66	3050 }	—2205	8.33	33.37	—265	Lower barometer at station 7; upper barometer at station 6.

HUM-PAH-YA-MUP PASS.

Station.	Date.	Hour.	At station. Barometer.	At station. Ther. attached.	At station. Ther. detached.	At Pose creek depot camp. Barometer.	At Pose creek depot camp. Ther. attached.	At Pose creek depot camp. Ther. detached.	Height of station in feet. Above mean tide.	Height of station in feet. Previous station.	Distance in miles from— Previous station.	Distance in miles from— Station 1.	Grade per mile from last station.	Remarks.
	1853.			°	°		°	°						
1	Aug. 11	12 m ...	27.432	83½	82	29.204	88	88	2558	....	....	....	......	Astronomical station on Kern river.
2	11	6 p. m..	27.314	76	75	29.179	80	80	2632	74	5.75	5.75	13	
3	14	10 a. m..	27.255	80	80	29.283	85	85	2815	183	6.28	12.03	29	
8	14	12 m	27.180	95	95	29.270	95	95	2950	135	3.78	15.81	36	
9	15	9 a. m..	26.800	82	82	29.298	86	86½	3332	382	4.25	20.06	90	Camp.
10	15	8 a. m..	24.954	86	78	26.780	78	78	5351	2019	7.00	27.06	288	Summit—lower barometer in camp.
11	....	....	....	......	......	....	......	......	3096	—2255	8.33	35.39	—272	Great Basin.

APPENDIX C—Continued.

TAH-EE-CHAY-PAH PASS.

Station.	Date.	Hour.	At station. Barometer.	Ther. attached.	Ther. detached.	At camp on summit 3953 feet a. m. t. Barometer.	Ther. attached.	Ther. detached.	Height of station in feet. Above mean tide.	Previous station.	Distance in miles from — Previous station.	Station 12.	Grade per mile from last station.	Remarks.
	1853.			°	°		°	°						
12	Aug. 19	11.30 a m.	26.570	80	80	26.220	80	80	3568					
13	19	10 a. m....	26.300	80	80	26.230	80	80	3876	308	4.25	4.25	72	
14	19	9.20 a. m.	26.230	78	78	26.180	78	78	4008	132	1.50	5.75	88	Dry lake.
15	....	....	....	......	......	....	......	......	3953	— 55	7.57	13.32	— 8	Camp.
16	Aug. 18	8.25 a. m.	27.080	72	72	26.260	72	72	3075	—878	5.60	18.92	—157	
17	18	9.30 a. m.	27.400	73	73	26.260	73	73	2737	—338	2.84	21.76	—119	
18	18	10.05 a. m.	27.690	74	74	26.261	74	74	2433	—304	1.56	23.34	—192	
19	18	11.50 a. m.	28.290	78.5	78.5	26.248	78.5	78.5	1785	—648	3.68	27.02	—176	
20	18	12.40 p. m.	28.580	78.5	78.5	26.248	78.5	78.5	1489	—296	1.98	20.00	—153	Tulare valley.

TEJON RAVINE.

Date.	Hour.	Stat'n	Distances from — Previous station.	Depot camp.	Level altitudes of station above — Previous station.	Depot camp.	Grade per mile from last station.	Upper station. Barometer.	Ther. attached.	Ther. detached.	Depot camp. Barometer.	Ther. attached.	Ther. detached.	Barometer altitudes of station above — Previous station.	Depot camp.	Difference of barometer and level altitudes.
1853.			*Feet.*			*Feet.*			°	°		°	°	*Feet.*	*Feet.*	
Sept. 17	....	1	......	......	....	2335.1										
17	6 p. m....	2	6200	......	— 2.1	2333.0	— 18	26.278	62	61	28.562	68	68	....	2327.3	5.7
17	5 p. m....	8	2728	......	— 39.0	2294.0	— 75	26.328	73	72	28.562	73	73	1.4	2328.7	—34.7
17	4 p. m....	18	3815	......	—164.2	2129.8	— 227	26.512	82	76	28.640	75	75	—127.5	2201.2	—71.4
17	12 m.......	23	2130	......	—392.8	1737.0	— 974	26.888	83	75	28.649	75	75	—401.3	1799.9	—62.9
17	11.30 a. m.	30½	2065	......	—352.6	1384.4	— 902	27.242	80	73	28.621	72	72	—411.1	1388.8	— 4.4
17	10 a. m....	34	1128	......	—226.5	1157.9	—1110	27.475	73.5	67	28.623	72	70	—249.7	1139.1	18.8
17	9 a. m....	40	1575	......	—218.7	939.2	— 733	27.695	72	70	28.625	65	64.5	—224.4	914.7	24.5
17	8½ a. m...	46	1800	......	—170.3	768.9	— 500	27.866	72	70	28.618	65	65	—180.6	734.1	34.8
17	7.35 a. m.	52	3030	......	—243.1	525.8	— 425	28.078	66	64	28.604	64	64	—270.9	463.2	62.6
17	7.15 a. m.	53	2635	......	136.2	662.0	273	27.927	66	65	28.600	64	64	148.3	611.5	50.5
17	6.30 a. m.	54	4150	......	—173.1	488.9	— 220	28.068	53	53	28.589	53	53	—116.6	494.9	— 6.0

APPENDIX C—Continued.

TEJON PASS.

Date.	Hour.	Station.	Distances from— Previous station.	Distances from— Depot camp.	Level altitudes of station above— Previous station.	Level altitudes of station above— Depot camp.	Grade per mile from last station.	Upper station. Barometer.	Upper station. Ther. attached.	Upper station. Ther. detached.	Depot camp. Barometer.	Depot camp. Ther. attached.	Depot camp. Ther. detached.	Barometer altitudes of station above— Previous station.	Barometer altitudes of station above— Depot camp.	Difference of barometer and level altitudes.
1853.			Feet.	Feet.	Feet.	Feet.	Feet.		°	°		°	°	Feet.	Feet.	Feet.
Sept. 6	9 a. m	7	2783	2783	59.2	59.2	112.3	28.618	87	87	28.681	86	85	60.8	60.8	— 1.6
6	11 a. m.....	10	7444	10227	239.2	298.4	169.7	28.390	94	95	28.676	92	91	292.4	231.6	6
6	12.30 p. m..	11	5021	15248	184.5	482.9	194	28.195	101	93	28.671	95.5	94	498.2	205.8	— 15.3
6	4 p. m......	17½	4789	20037	217.4	700.3	239.7	27.950	96	95	28.637	96	96	726.8	228.6	— 26.5
7	8.30 p. m...	17½	... .	....	217.4	700.3	239.7	27.960	82	82	28.655	82	81	714.9	216.7	— 14.6
7	12 m..	24	3223	23260	165.2	865.5	270.6	27.782	94	92	28.650	94.5	93	917.2	202.3	— 51.7
7	1.30 p. m...	26	2736	25996	77.9	943.4	150.3	27.690	93	93	28.634	94	94			
8	8.25 a. m...	26	....	....	77.9	943.4	150.3	27.672	84	84	28.595	84	84	956.3	39.1	— 12.9
8	1.35 p. m...	45	8885	34881	382.2	1325.6	254	27.300	94	91	28.583	95	95	1365.2	408.9	— 39.6
8	3 p. m......	52	3570	38451	182.1	1507.7	276	27.115	95	93	28.570	98	97	1554.1	188.9	— 46.4
8	3.10 p. m...	52	....	....	....	1471.8	....	27.140	83	83	28.570	98	97	....	1474.9	— 3.1
8	6 p. m......	52	....	....	....	1471.8	....	27.090	70.5	71	28.519	86	85	....	1439.6	32 2
9	6 a. m......	52	....	....	....	1471.8	....	27.085	51	51.5	28.530	60	60.5	....	1411.3	60.5
9	9.40 a. m...	52	....	....	....	1471.8	....	27.162	82	80	28.590	81	80	....	1487.4	— 15.6
9	10 a. m.....	52	3570	42021	182.1	1507.7	....	27.126	83	82	28.590	80	80	....	1527	— 19.3
9	1.25 p. m...	62	3158	45179	106.5	1614.2	178	27.027	87	88	28.580	88	87	....	1644	— 29.8
9	2.20 p. m...	71	2094	47273	104.1	1718.3	262.5	26.395	87	86	28.572	94	94	82.7	1726.7	— 8.4
10	1.25 p. m...	102½	12035	59308	577.7	2296	253.4	26 470	86	81	28.676	92	90.5	605.4	2332.1	— 36.1
10	2.29 p. m...	106	2150	61458	109.7	2405.5	242	26.349	86	86	28.665	94	93	125.2	2457.3	— 51.6
10	4 p. m......	115	3714	65172	186.7	2592.4	268	26.162	84	81	28.650	91	91	191.4	2648.7	— 56.3
11	7 a. m......	125	5388	70560	202.3	2794.7	198.2	25.975	61.5	64	28.685	61	61	122.5	2771.2	23.5
12	9 a. m......	......	....	....	....	....	....	25.970	75	74	28.654	93	92	....	2819.9	— 25.2
12	12 m..	......	....	....	....	....	....	25.960	80	78	28.649	93	92	....	2852.2	—57.5
12	3 p. m......	......	....	....	....	....	....	25.970	100	84	28.585	95.5	94	....	2821.9	— 27.2
12	6 p. m......	......	... .	....	....	....	....	25.990	74	74	28.560	83	82	....	2700.4	— 94.7
13	8.10 a. m...	133	4867	75427	353.4	3148.1	383.4	25.630	76	70	38.605	72	72	348.1	3119.3	— 28.8
11	9.30 a. m...	......	....	....	....	....	....	24.965	76	74	28.720	80	80	....	4031.9	
11	10.50 a. m..	......	.....	....	....	....	....	24.925	77	74	28.720	80	80	....	4080.8	
11	11.30 a. m..	140	1650	77077	689.7	3837.8	2207	25 090	81	78	28.720	87	85	797.7	3917	— 79.2
11	1 p. m......	... ..	....	....	....	....	....	24.050	84	76	28.700	89	89	....	5142.3	
13	12.30 p. m..	151	3943	81020	—588.9	3248.9	728.3	25.514	75	75	28.630	87	87	—600.1	3316	— 68
13	1.15 p. m...	165	2921	83941	—147.6	3101.3	266.8	25.620	77	76	28.620	88	88	—121.7	3195.2	— 93.9
13	4 p. m.. ..	......	....	....	....	....	....	25.560	62	63	28.570	85	85	— 68.3	3126.9	— 25.6
13	6 p. m......	......	....	....	....	....	....	25.527	46	46	28.550	76.5	76	—153.7	3041.9	59.8
15	6 a. m......	......	....	....	....	....	....	25.472	48	48	28.550	54.5	55	—213.6	3103.3	— 2
15	9 a. m......	......	....	....	....	....	....	25.520	65	66	28.585	69.5	69	—115.5	3201.4	—100.1
15	12 m..	......	....	....	....	....	....	25.530	67.5	68	28.565	78.5	78	—133.5	3183.4	— 82.1
15	3 p. m......	......	....	....	....	....	....	25.505	68	70	28.632	81	80	— 30.4	3286.5	—185.2
15	6 p. m......	......	....	....	....	....	....	25.470	59	61	28.615	74	73.5	....	3250.2	—148.9
14	7.45 a. m...	172	2457	86398	— 93.1	3008.2	200.1	25.561	60	60	28.605	63	63	— 88.5	3038.4	— 30.2
14	10.10 a. m..	191	6205	92603	—290.4	2717.8	247.1	25.954	71.5	71.5	28.640	72	72	—220.1	2809.3	— 91.5
14	10.50 a. m..	198	2045	94648	— 56.9	2060.9	146.9	25.988	74.5	74.5	28.635	76	76	— 24.7	2784.6	—123.7
14	12 m..	206	3070	97718	—104.1	2556.8	179	26.069	74.5	74.5	28.620	78.5	76.5	—110.2	2674.4	—117.6
14	1 p. m......	212	5039	102757	—228	2328.8	238.3	26.279	75	75	28.610	80	80	—234.2	2440.2	—111.4
14	4.20 p. m...	213	3000	105757	—120.1	2208.7	211.4	26.379	79	76	28.570	79	79	—135.6	2304.6	— 95.9
14	4 p. m......	214	3338	109095	—112	2096.7	177.1	26.499	79	78	28.576	80	80	—121.1	2183.5	— 83.8
14	2.30 p. m...	217	3373	112468	— 95.3	2001.4	149.2	26.595	83	82	28.594	83	82	— 69	2114.5	—113.1
14	3 p. m......	218	2317	114785	— 60.6	1940.8	138.1	26.648	87	84	28.589	82	81	— 78.1	2036.4	— 95.6

APPENDIX C—Continued.

CAÑADA DE LAS UVAS.

Date.	Hour.	Station	Distances from— Previous station.	Distances from— Depot camp.	Level altitudes of station above— Previous station.	Level altitudes of station above— Depot camp.	Grade per mile from last station.	Upper station. Barometer.	Upper station. Ther. attached.	Upper station. Ther. detached.	Depot camp. Barometer.	Depot camp. Ther. attached.	Depot camp. Ther. detached.	Barometer altitudes of station above— Previous station.	Barometer altitudes of station above— Depot camp.	Difference of barometer and level altitudes.
1853.			*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		°	°		°	°	*Feet.*	*Feet.*	*Feet.*
		11	23000	....	—485.9	—485.9	—111.5									
		14	6500	29500	—104.3	—590.2	— 84.7									
		30	29000	58500	463.8	—126.4	84.5									
Sep. 28	5 p. m	37&58	9240	67740	319.8	193.4	169	28.425	85	86	28.595	72	72	....	213.4	— 20
28	4.15 p. m...	56	3139	70879	190.9	384.2	321.1	28.240	87	84	28.609	78	78	190.3	403.7	— 19.4
28	3.15 p. m...	49	5092	75971	336.1	720.4	348.5	27.900	79	79	28.623	84	83	325.7	729.4	— 9
28	2.15 p. m...	40	3266	79237	197.3	917.7	319	27.718	77.5	77	28.634	82	82	200.1	920.5	— 11.8
28	1.20 p. m...	34	2237	81474	138	1055.8	326	27.600	81.5	81	28.652	80	80	152	1081.5	— 25.7
28	12.30 p. m...	27	2087	83561	102.8	1158.6	260.1	27.520	85	81	28.660	80	80	....	1205.3	— 46.7
28	12 m........	22	1751	85312	102.2	1260.8	308.1	27.420	75.5	75	28.666	79.5	79	65.7	1271	— 10.2
28	11 a. m......	18	2407	87719	126.2	1387	276.7	27.305	78	77.5	28.674	76.5	76 5	145.2	1416.2	— 29.8
28	10 a. m......	14	1675	89394	79.6	1466.6	250.9	27.240	71.5	71.5	28.682	74	73	65.8	1482	— 15.4
28	9 a. m......	7	2602	91966	161.4	1628	327.5	27.080	66	65.5	28.690	71.5	71	140	1622	6
30	7.40 a. m...	1	3373	95369	146.4	1774.4	229.2	26.922	72	70	28.644	70	70	147.6	1769.6	4.8
29	6 p. m......	Camp.	......	....	....	1764	....	26.835	67	67	28.560	77.5	77	....	1750	14
30	6 a. m......	Camp.	......	....	....	1764	....	26.860	56	58	28.609	59.5	60	....	1746	18
Oct. 1	6 a. m......	Camp.	......	....	....	1764	....	27.000	67	65.5	28.688	65	66	....	1716	48
4	6 p. m......	Camp.	......	....	....	1764	....	26.987	70	70	28.680	80	80.5	....	1721	43
5	6 a. m......	Camp.	......	....	....	1764	....	26.973	49	51	28.724	73	72.5	....	1692	72
Sep. 30	8 a. m......	3	2363	97732	35.3	1809.7	79	26.898	74	70	28.656	73.5	73	38.9	1808.5	1.7
30	8.20 a. m...	6	2141	99873	64.3	1874	159	26.861	75	73	28.664	76.5	76	52.6	1861.1	12.9
30	8.45 a. m...	9	2551	102424	57.1	1931.1	118	26.810	77	74	28.672	78.5	78	68.5	1929.6	1.4
30	9 a. m......	10	2150	104574	36.6	1967.7	90	26.790	81	75	28.680	80.5	80	41.4	1971	— 3.3
30	10 a. m......	12	3983	108557	77.3	2045	103	26.744	83	79	28 678	84.5	84	58	2029	16
30	11.05 a. m...	15	3610	112167	61.1	2160	89	26.640	82	81	28.676	91	90	106.2	2135.2	— 29
30	1.25 p. m...	18	9215	121382	266.4	2372 5	153	26.364	85	83	28.662	95	94	303.1	2438.3	— 65.8
30	2.30 p. m...	22	4478	125860	246.1	2618.6	290	26.152	85	84	28.654	94	94	235.5	2673.8	— 55.2
30	3.15 p. m...	27	2974	128834	190.9	2809.5	339	25.960	82	82	28.646	94	93	194.9	2868.7	— 59.2
Oct. 1	10.30 a. m...	31	3187	132021	— 51.5	2758	— 85	26.137	84	84	28.759	90	89	— 74.7	2794	— 36
1	11.40 a. m...	33	3864	135885	—322.8	2435.2	—441	26.428	83	89	28.758	92	92	—333.1	2460.9	— 25.7
1	1.10 p. m...	38	4505	140390	— 55	2280.2	— 64	26.547	84	84	28.738	94.5	94.5	—146.5	2314.4	— 34.2
1	3 p. m......	40	5705	146095	—148.8	2131.4	—138	26.684	86	86	28.715	96	95	—170	2144.4	— 13
1	4.30 p. m...	45	7205	153300	— 63	2068.4	— 46	26.726	86	88	28.700	61	91	— 71.9	2072.5	— 4.1
2	10.15 a. m...	47	2900	15[illegible]	103.6	2172	189	26.710	86.5	84	28.780	85.5	85.5	117.7	2190.2	— 18.2
2	11 a. m......	51	2504	158704	—169.3	2002.7	—357	26.838	86	85	28.769	88	88	—152.9	2037.3	— 34.6
2	12 m........	53	2471	161175	— 93	1909.7	—199	26.930	90	89	28.758	93	92	—100.5	1936.8	— 27.1
2	12.30 p. m...	55	2710	163885	4.7	1914.4	9	26.910	93	90	28.757	93	92	30.8	1967.6	— 53.2
2	1.30 p. m...	58	4103	167988	39.7	1874.7	51	26.950	90	90	28.754	93	93	55.1	1912.5	— 37.8
2	2.30 p. m...	61	7372	175360	47.6	1922.3	34	26.882	91	89	28.752	94	93	71	1983.5	— 61.2
2	4 p. m......	64	4572	179932	— 52.7	1869.6	— 61	26.930	91.5	87	28.750	93	98	— 49.7	1933.8	— 64.2
3	8.30 a. m...	66	2864	182796	— 51.9	1817.7	— 96	27.070	78	80	28.804	81	81.5	—108.6	1825.2	— 7.5
3	9 a. m......	68	3257	186053	— 67.3	1750.4	—109	27.128	86.5	86.5	28.813	85	84.5	— 52.5	1772.7	— 22.3
3	10.45 a. m...	74	6262	192315	— 71.9	1678.5	— 61	27.196	90	89	28.800	91	90	—133.5	1639.2	— 14.7
2	6 a. m......	Camp.	......	....	....	1772.4	....	26.965	44	45	28.728	63	65	....	1666.2	106.2
2	6 p. m......	Camp.	......	....	....	....	....	27.018	75	76	28.730	76.5	74	....	1765.2	7.2
3	6 a. m......	Camp	......	....	....	....	....	26.990	47.5	48	28.735	63	62.5	....	1704.8	67.6
3	11.30 a. m...	Camp.	......	....	....	....	....	27.090	88	87.5	28.787	93	93	....	1785.1	— 12.7
3	12 m........	Camp.	......	....	....	....	....	27.067	88	88	28.782	95.5	95	....	1780.8	— 8.4
3	3 p. m......	Camp.	......	....	....	....	....	27.025	86	87	28.732	96	95.5	....	1788.9	— 16.5
3	6.20 p. m...	Camp.	......	....	....	....	....	26.965	62	62	28.710	81	80	....	1739	33
4	6 a. m......	Camp.	......	....	....	....	....	26.975	48.5	50	28.751	73	73	....	1714	58.4

APPENDIX C—Continued.

SAN FRANCISQUITO PASS.

Station.	Date	Hour.	At station. Barometer.	At station. Ther. attached.	At station. Ther. detached.	At Benicia, 81.6 feet a. m. t. Barometer.	At Benicia, 81.6 feet a. m. t. Ther. attached.	At Benicia, 81.6 feet a. m. t. Ther. detached.	Height of station, in feet. Above mean tide.	Height of station, in feet. Previous station.	Dist'ce, in miles, from— Previous station.	Dist'ce, in miles, from— Station.	Grade per mile from previous station.	Remarks.
	1853.			°	°		°	°						
1	Oct. 13	1.15 p. m...	27.553	93	79	30.050	71	71	2637	....	....	....	....	In Great Britain.
2	13	12.15 p. m.	27.328	90	78	30.050	71	71	2863	226	2.07	2.07	109	
3	13	11.25 a. m.	26.760	82	72	30.060	68	68	3430 }	574	1.75	3.82	328	Summit of the pass.
3	13	3 p. m.....	26.735	86	76	30.019	77	77	3445 }					
4	13	3.20 p. m..	26.853	86	77	30.010	77	77	3315	—122	0.35	4.17	—350	Lake Elizabeth.
5	15	9.25 a. m..	26.505	83	75	30.100	62	54	3718	403	0.43	6.60	166	Summit of spur.
6	15	9.05 a. m..	26.915	85	75	30.100	62	54	3292	—426	0.93	7.53	—457	
7	15	8.10 a. m..	27.265	71	71	30.100	62	54	2878 }					
7	15	6 a. m.....	27.195	48	48	30.060	56	52	2763 }	—420	1.73	9.26	—243	Camp.
7	14	6.45 p. m..	27.200	63	63	30.040	65	65	2867 }					
8	14	6 p. m.....	27.540	71	71	30.020	65	65	2543	—329	1.61	10.87	—204	
9	14	4.20 p. m..	27.938	83	77	29.990	77	77	2144	—399	2.00	12.87	—200	
10	14	3.40 p. m..	28.057	84	84	29.990	77	77	2038	—106	1.00	13.87	—106	
11	14	2.30 p. m..	28.200	86	85	29.990	77	77	1898	—140	1.48	15.35	— 95	
12	14	1.42 p. m..	28.310	89	87	29.999	76	75	1805	— 93	1.49	16.84	— 62	
13	14	12.42 p. m.	28.465	89	85	30.020	76	70	1655	—150	1.80	18.64	— 83	
14	14	11.35 a. m.	28.640	84½	83	30.020	70	70	1480	—175	1.55	20.19	—110	Five miles from Santa Clara valley.

NEW PASS.

Station.	Date.	Hour.	At station. Barometer.	At station. Ther. attached.	At station. Ther. detached.	Mohave Depot camp, 2664 ft. a. m. t. Barometer.	Mohave Depot camp, 2664 ft. a. m. t. Ther. attached.	Mohave Depot camp, 2664 ft. a. m. t. Ther. detached.	Height of station, in feet. Above mean tide.	Height of station, in feet. Previous station.	Dist'ce, in miles, from— Previous station.	Dist'ce, in miles, from— Station 1.	Grade per mile from last session.	Remarks.
	1853.			°	°		°	°						
1	Oct. 25	6 a. m.....	26.970	50½	51	27.157	36	36	2889	....	....	....	....	In Great Basin.
5	25	9 a. m.....	27.147	64	60	27.300	74	73½	2795	— 94	5.25	5.25	— 18	
6	25	12 m.......	27.060	72	64	27.258	78½	74	2853	58	1.23	6.48	47	
7	25	11.30 a. m..	26.980	76	64	27.272	78½	74	2962	109	0.51	6.99	218	
9	25	1 p. m.....	26.785	78	68	27.258	78½	74	3164	202	0.84	7.83	240	Divide.
10	25	2.15 p. m ..	26.900	75	69	27.247	77	77	3025	—139	1.80	9.63	— 77	
12	25	4 p. m......	27.250	78	68	27.242	77	78	2644	—381	3.68	13.31	—105	
15	25	5 p. m......	27.390	66	62	27.240	63	63	2519	—125	1.79	15.10	— 70	
22½	26	5 p. m......	27.800	55	54	27.390	54	54	2258	—261	4.16	19.26	— 62	
24½	28	8 a. m......	28.200	71	68	27.625	58	58	2123	—135	1.72	20.98	— 78	
35	28	1.30 p. m ..	28.560	79	78	27.725	83	83	1790	—333	5.74	26.72	— 58	
40½	28	5 p. m......	28.683	76	75	27.660	62½	62½	1670	—120	3.16	29.88	— 37	Near Santa Clara valley.

APPENDIX C—Continued.

SAN FERNANDO PASS.

Station.	Date.	Hour.	At station.			At Mohave Depot camp, 2664 feet a. m. t.			Height of station in feet.		Distance in miles from—		Grade per mile from last station.	Remarks.
			Barometer.	Ther. attached.	Ther. detached.	Barometer.	Ther. attached.	Ther. detached.	Above mean tide.	Previous station.	Previous station.	Station 3.		
	1853.			°	°		°	°						
3	Oct. 30	7 a. m....	29.050	57	57	27.610	50	50	1286	....	......	......	....	Santa Clara valley.
7	30	8.30 a. m.	28.940	76	75	27.685	73½	73	1400	114	2.68	2.68	43	
12	30	9.30 a. m.	28.610	83	76	27.685	74	74	1746	346	1.34	4.02	260	
15	30	10 a. m....	28.610	83	76	28.425	85	82	1940	194	0.22	4.24	881	Lower station, station 12; upper station, station 15.
16	30	11 a. m....	28.635	92	81	28.610	83	76	1746	—194	0.10	4.34	—1940	Lower station, station 12; upper station, station 16.
23	30	1.20 p. m.	29.245	97	92	27.628	91	91	1048	—698	4.44	8.78	— 157	Near San Fernando mission.
23	31	6.30 a. m.	29.095	73	71	27.362	30	30						

CAJON PASS.

Station.	Date.	Hour.	At station.			At Mohave Depot camp.			Height of station in feet.		Distance in miles from—		Grade per mile from previous station.	Remarks.
			Barometer.	Ther. attached.	Ther. detached.	Barometer.	Ther. attached.	Ther. detached.	Above mean tide.	Previous station.	Previous station.	Station 55.		
	1853.			°	°		°	°						
55	Nov. 5	8 a. m....	27.955	67	56	27.472	70	70	2167					
56	5	8½ a. m...	27.880	70	58	27.472	73	73	2240	73	1.28	1.28	57	
57	5	9½ a. m...	27.665	87	70	27.742	73	73	2512	272	2.33	3.61	117	
58	5	10½ a. m...	27.445	86	73	27.466	87	77	2681	169	1.67	5.28	101	
59	5	12 m	27.320	82	77	27.460	89.5	80	2791	110	1 22	6.50	90	
60	5	1 p. m....	27.160	79	74	27.444	85	81	2947	156	1.10	7.60	142	
63	5	3 p. m....	26.685	76	70	27.412	84	84	3416	469	2.68	10.28	171	
65	5	5 p. m....	26.242	65	62	27.380	75	75	3840	424	2.65	12.94	159	
66	5	6 p. m....	25.740	55	55	27.369	68	68	4343	503	0.96	13.90	524	
67	6	10.30 a. m.	25.395	55	55	27.290	73	73	4636	293	0.23	14.13	1271	40 ıeet below summit.
68	6	11.30 a. m.	25.789	60	58	27.280	87	77	4179	—457	2.21	16.34	—207	
69	Oct. 21	11 a. m....	26.760	84	79	27.569	82	82	3536	—643	6.90	23.24	— 93	
70	21	7.40 a. m..	27.200	77	68	27.469	44	43	3026	—510	5.80	29.04	— 88	
71	....	....	....	....	....	....	......	......	2664	—362	4.23	33.27	— 86	Mohave Depot camp.

APPENDIX C—Continued.

FROM MOHAVE DEPOT CAMP, DOWN THE MOHAVE.

Station.	Date.	Hour.	At station. Barometer.	At station. Ther. attached.	At station. Ther. detached.	At Benicia, 81.6 feet a. m. t. Barometer.	At Benicia, 81.6 feet a. m. t. Ther. attached.	At Benicia, 81.6 feet a. m. t. Ther. detached.	Height of station in feet. Above mean tide.	Height of station in feet. Previous station.	Distance in miles from— Previous station.	Distance in miles from— Station 1.	Grade per mile from last station.	Remarks.
	1853.			°	°		°	°						
1	....	....	....	......	......	....	......	......	2664	....	....	....	......	Mohave Depot camp.
2	Nov. 9	6.30 a. m.	27.955	29	30	30.330	56	50	2227	—477	19.70	19.70	—24	
3	9	3.30 p. m.	28.102	67	65	30.250	68	67	2157	—111	14.00	33.70	— 8	2116 a. m. t.
3	10	6.30 a. m.	27.982	35	35	30.200	59	55	2076					
4	10	5 p. m....	28.292	63	63	30.190	66	65	1898					
4	11	6 a. m....	28.300	43	43	30.180	53	50	1796					
4	17	5.30 p. m.	28.225	59	59	30.100	65	54	1844	—296	24.6	58.3	—12	1820 a. m. t.
4	18	12 m......	28.432	70	67	30.200	68	60	1781					
4	18	3 p. m....	28.390	67	65	30.170	68	59	1781					
5	13	12 m......	29.040	78	77	30.090	61	61	1166					
5	13	3 p. m....	28.985	78	77	30.090	63	62	1179	—742	31.2	89.5	—23	1078 a. m. t.
5	14	6 a. m....	28.921	43	44	29.990	63	52	1060					
5	14	9 a. m....	29.005	67	61	30.000	60	58	1040					
6	15	3 p. m....	28.965	78	76	30.000	59	57	1137	59	6.4	95.9	9	1137 a. m. t., spring near Dry Lake.

SAN GORGONIO PASS.

Station.	Date.	Hour.	At station. Barometer.	At station. Ther. attached.	At station. Ther. detached.	At Benicia, 81.6 feet a. m. t. Barometer.	At Benicia, 81.6 feet a. m. t. Ther. attached.	At Benicia, 81.6 feet a. m. t. Ther. detached.	Height of station in feet. Above mean tide.	Height of station in feet. Previous station.	Distance in miles from— Previous station.	Distance in miles from— Station 3.	Grade per mile from last station.	Remarks.
	1853.			°	°		°	°						
3	Nov. 11	9 a. m....	29.029	64¼	58	30.115	56	52	1118	....	....	....	......	Valley of Santa Anna river.
3	11	12 m	29.[illegible]74	71½	70	30.165	60	59	1151	....	....	....	......	Station 3, 120 feet a. m. t.
3	11	3 p. m....	29.047	78	78	30.135	64	64	1170	....	....	....	......	
3	11	Sunset	29.051	64	63	30.175	60	60	1154	....	....	....	......	
3	12	Sunrise ...	29.006	38	37	30.170	54	50	1092	....	....	....	......	
4	12	11.20 a. m.	28.865	86	74	30.155	62	62	1378	258	6.26	6.26	41	
5	12	1.15 p. m.	28.599	85½	83½	30.155	62	62	1667	289	3.86	10.12	75	
6	12	1.45 p. m.	28.421	85	80	30.155	63	63	1837	170	1.34	11.46	127	
7	12	2.30 p. m.	28.238	87	78½	30.125	64	64	1992	155	2.00	13.46	77	
8	12	Sunset	27.982	76	71	30.125	58	58	2205	213	2.71	16.17	79	
9	13	10 a. m....	27.390	79½	74	30.100	60	60	2808	603	8.33	24.50	72	Divide.
10	14	8.40 a. m.	27.898	66½	64	30.015	60	58	2142	—666	7.00	31.50	95	
11	14	9.40 a. m.	28.179	70	66½	30.015	60	58	1876	—266	2.09	33.59	132	
12	14	Sunset	28.965	74	73	30.010	58	50	1117	—767	12.94	46.53	60	Station 12, a. m. t.
12	15	Sunrise ...	28.974	62	62	30.035	52	48	1101					
13	15	Sunset	29.530	70	70	30.025	60	50	572	—537	6.01	52.54	89	
14	16	3 p. m....	29.912	86½	85	29.935	63	48	170	—412	10.37	62.91	40	A. m. t., 160.
14	16	Sunset	29.893	68	67	29.950	63	48	150					
15	17	3 p. m....	30.142	74	73	30.105	64	58	76	....	....	....	......	A. m. t., 85.
15	17	Sunset	30.122	70	68½	30.120	65	51	94	— 75	15.82	78.73	4½	Colorado desert.

APPENDIX C—Continued.

COLORADO DESERT, FROM STATION 15, OF SAN GORGONIO PASS, TO FORT YUMA WAGON-ROAD.

Station.	Date.	Hour.	At station.			At Benicia, 81.6 feet a. m. t.			Height of station, in feet.		Distance, in miles, from—		Grade per mile from last station.	Remarks.
			Barometer.	Ther. attached.	Ther. detached.	Barometer.	Ther. attached.	Ther. detached.	Above mean tide.	Previous station.	Previous station.	Station 15.		
	1853.			°	°		°	°						
15	....	....	....	......	......	....	......	......	85					
16	Nov. 18	9.15 a. m..	30.440	75	71	30.215	65	63	−99	−175	8.80	8.80	....	Watering place.
16	18	12 m.......	30.427	84½	80	30.200	67	56	−81					
17	18	4 p. m.....	30.248	76	76	30.185	68	59	46	136	2.54	11.34	....	Point of rocks, 100 feet below water line.
18	20	9.15 a. m..	30.473	62	60	30.305	61	59	−69					
18	20	12 m.......	30.452	74	72¼	30.285	63	62	−42					
18	20	3 p. m.....	30.438	80½	80	30.255	64	65	−44	−116	30.43	41.77		
18	20	Sunset.....	30.384	72	72	30.235	61	56	−25					
18	21	Sunrise....	30.336	39	38½	30.255	55	46	−32					
19	21	1.45 p. m..	30.152	86½	84	30.235	63	58	227	299	12.18	53.95		
20	21	5.10 p. m..	29.998	76	75	30.205	63	57	312	85	5.45	59.40	....	Wagon-road.

FROM CARRIZO CREEK TO FORT YUMA.

Station.	Date.	Hour.	At station.			At Benicia, 81.6 feet a. m. t.			Height of station, in feet.		Distance, in miles, from—		Grade per mile from last station.	Remarks.
			Barometer.	Ther. attached.	Ther. detached.	Barometer.	Ther. attached.	Ther. detached.	Above mean tide.	Previous station.	Previous station.	Station 1.		
	1853.			°	°		°	°						
1	Nov. 22	Sunrise....	29.725	46	44½	30.135	54	48	431	....	....	....	....	Camp at Carrizo creek.
2	Dec. 4	8.25 a. m..	29.914	60	58	30.230	59	51	374	— 57	3.67	3.[illegible]	— 16	
3	4	8.40 a. m..	29.960	65	61	30.230	59	51	346	— 28	0.67	4.34	— 42	
4	4	8.50 a. m..	29.870	69	69	30.230	59	51	443	97	0.66	5	144	On top of hill.
5	4	9.30 a. m..	29.940	78	76	30.230	59	51	406	— 37	1.90	6.90	— 20	
6	4	10.50 a. m.	30.040	86	78	30.164	61	55	246	—160	1.67	8.57	—100	
7	4	11.40 a. m.	30.040	85	79½	30.130	63	57	229	— 17	1.54	10.11	— 11	
8	4	2 p. m.....	30.129	89	81	30.063	64	60	91	—138	5.91	16.02	— 23	
9	4	3.45 p. m..	30.200	89½	79	30.020	64	62	— 16	—107	3.32	19.34	— 32	
10	4	5.45 p. m..	30.170	70	70	29.990	64	60	— 70	— 54	4.58	23.92	— 12	Big Laguna.
11	5	9.45 a. m..	30.240	73	66	30.090	60	54	— 21	49	6.57	30.49	8	
12	5	12.30 p. m.	30.200	85	76	30.100	61	58	56	77	7.03	37.52	11	
13	5	3 p. m.....	30.160	93	78	30.120	62	62	132	76	5.05	42.57	15	
14	6	6 a. m.....	30.180	46	46	30.030	52	45	— 70	—202	5.80	48.37	— 35	Alamo Mocho.
15	6	9.15 a. m..	30.230	65	64	30.130	53	46	24	94	5.20	53.57	18	
16	6	12.15 p. m.	30.200	84	77	30.170	56	47	132	108	6.34	59.91	17	
17	6	2.40 p. m..	30.200	87	82	30.210	49	49	170	38	4	63.91	9	
18	6	Sunset.....	30.185	84	75	30.190	47	47	156	— 14	4.43	68.34	— 4	
19	7	6.45 a. m..	30.200	62	62	30.130	43	43	62	— 94	1.14	69.48	— 82	Cook's well.
20	7	9 a. m.....	30.260	77	73	30.150	45	45	47	— 15	5.91	75.39	— 3	
21	7	11 a. m....	30.260	82	76	30.120	46	46	25	— 22	2.31	77.70	— 7	
22	7	11 a. m....	30.260	84	78	30.120	46	46	30	5	1.33	79.03	4	
23	7	11.30 a. m.	30.225	78	75	30.120	48	48	46	16	1.63	80.66	10	Algodones, Colorado river.

APPENDIX C—Continued.

WARNER'S PASS.

Station.	Date.	Hour.	At station.			At Benicia, 81.6 feet a. m. t.			Height of station in feet.		Distance in miles from—		Grade per mile from last station.	Remarks.
			Barometer.	Ther. attached.	Ther. detached.	Barometer.	Ther. attached.	Ther. detached.	Above mean tide.	Previous station.	Previous station.	Station 1.		
	1853.			°	°		°	°						
1	Nov. 29	12 m	27.429	76	75	30.230	61	58	2869	....	....	....	....	Camp near Warner's.
1	29, 30	3 p. m. ..	27.383	76	69½	30.255	64	61	2924	....	....	....	....	Do.
1	30	Sunrise ...	27.315	35½	34	30.365	57	51	2865	....	....	....	....	Do.
1	Dec. 1	7.30 a. m.	27.296	52	48	30.370	63	60	2987	....	....	....	....	Do.
2	Nov. 28	1.35 p. m.	27.307	65	64	30.315	64	64	3020	109	2.85	2.85	38	
3	28	12.30 p. m.	27.028	61	59	30.295	63	61	3226	206	3.23	6.08	64	
4	28	12 m	26.808	59	58	30.295	63	61	3495	269	1.25	7.33	215	
5	28	11.30 a. m.	26.548	54½	54	30.295	63	61	3764 }	285	1.02	8.35	280	Divide.
5	Dec. 1	11.20 a. m.	26.550	69	66	30.300	68	62	3795 }					
6	Nov. 28	10.45 a. m.	27.059	59	55	30.285	64	60	3217	—563	1.69	10.04	—333	
7	28	9.15 a. m.	27.602	66	61	30.285	64	57	2666	—551	3.92	13.96	—140	
8	28	8.30 a. m.	27.759	64	56	30.285	64	57	2490	—176	2.21	16.17	— 80	
9	23	2.50 p. m.	27.854	75	74	29.995	64	63	2213	—277	3.67	19.84	— 76	Base of hill.
10	23	12.30 p. m.	27.568	81	79	30.025	60	56	2557	244	5.72	25.56	60	
11	23	12.20 p. m.	27.541	85	82	30.025	60	56	2604	47	0.05	25.61	940	Summit.
12	23	12.10 p. m.	27.608	87	78	30.025	60	56	2530	— 74	0.10	25.71	—740	
13	23	11.25 a. m.	27.505	77	76	30.025	60	56	2602	72	1.00	26.71	72	
14	23	10.40 a. m.	27.650	69	68	30.040	58	53	2424	—178	1.10	27.81	—165	
15	23	9.40 a. m.	27.926	78	74	30.050	57	51	2193	—231	1.20	29.01	—192	
	23	8.20 a. m.	28.219	64	64	30.055	55	49	1850	—343	2.64	31.65	—130	Base of hill.
	23	8.15 a. m.	28.077	61½	61½	30.055	55	49	1977	127	0.11	31.76	1155	Top of hill.
		8 a. m....	28.344	67	62	30.055	55	49	1732	—245	0.32	32.08	—766	
	22	2 p. m....	28.792	78	77	30 075	66	61	1353	—379	6.05	38.13	— 63	
	22	12.20 p. m.	29.075	87	82	30.100	63	56	1133	—220	3.03	41.16	— 73	
	22	11 a. m....	29.286	84	81½	30.115	62	54	934	—199	2.50	43.66	— 80	
22	22	9.20 a. m.	29.513	83	76	30.145	59	50	743	—191	2.84	46 50	— 66	
23	22	8.20 a. m.	29.628	73	68	30.145	59	50	602	—141	2.65	49.15	— 53	
24	22	Sunrise ...	29.725	46	44½	30.135	54	48	431	—171	4.16	53.31	— 41	Camp at Carrizo creek.
25	21	5.15 p. m.	29.99[illegible]	76	75	30.205	63	57	312	—119	11.01	64.32	— 11	Wagon road in the desert.